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Asian Biotechnology and Development Review

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Special Issue on Biofuels and South Asia: Policy Options

Guest Editor: **K.V. Raju**

- Biofuels in South Asia: An Overview
  K.V. Raju
- Improved Livelihoods and Environmental Protection through Biodiesel Plantations in Asia
  Suhas P. Wani, M. Osman, Emmanuel D'Silva, and T.K. Sreedevi
- Liquid Biofuels in South Asia: Resources and Technologies
  Linoj Kumar NV, Prabha Dhavala, Anandajit Goswami, and Sameer Maithel
- Biofuel Laws in Asia: Instruments for Energy Access, Security, Environmental Protection and Rural Empowerment
  M P Ram Mohan, G T Thomas Phillippe and M V Shiju
- Biofuels and WTO: An Emerging Context
  R S Deshpande

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Biofuels in South Asia: An Overview

Editorial Introduction

K.V.Raju*

Increasing energy demand and spiraling oil prices are putting financial strain on countries and also causing environmental degradation. Energy security has assumed greater significance than ever as energy consumption, food production, improved livelihoods and environmental quality are interrelated. Asian countries with dense population are more prone to energy crises than to their counterparts in the world. All countries in this region are net importers of petroleum fuels. In this context, as an indigenous and renewable energy source, use of biofuels can play a vital role in reducing the dependence on petroleum import and catalysing the rural economic development. In the last few years, interest in these green fuels has grown dramatically followed by the equivalent market responses.

Biofuels are presently receiving much worldwide attention. The bright prospects are primarily driven by Brazil, the United States and Europe. The trend continues in some Asian economies largely because of the increased economic activity, which has resulted in high growth of primary energy demand specifically for industrial and transportation use. The biofuel use may ease supply security of high energy consuming Asian economies. It is also being looked as environmentally safe fuel, which may contribute in reducing green house gases.

South Asia, with a geographical area of 5.1 million hectares, is home to 1.5 billion people and is witnessing a sustained and rapid economic growth. As a result primary energy demand in this part of the globe has increased by 64 per cent since 1991 reaching 584 million ton in 2003-04. In this context, liquid biofuels as an alternative energy source can play a significant role in the energy scene of this region.

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Recent developments have made these fuels economically interesting in view of the resource potential and the possibility of improving environmental performance, along with employment generation and empowerment of the rural economy. However, development of this biomass-based energy sector would require assured availability of resources and efficient technologies to keep pace with society's need for these clean and viable alternatives.

It is now a well-accepted fact that biofuels have lower environmental externalities and is acceptable on well-acknowledged environmental standards. This brings in the issue of international environmental agreements and increased use by environmentally conscious countries. It is known that most developed and developing countries spend huge foreign exchange on oil imports. Therefore, these countries would like to introduce use of biofuels aggressively by cutting down the cost of production and subsidising to the effect of impacting aggregate trade. The literature emerging from developed countries suggests that the arguments regarding trade in bio-fuels will surface on four counts in future discussion. First, it will feature in market access context from the point of view of the net exportable countries. Second, the support measures to the farmers will get into discussions especially in the context of comparison between developed and developing countries. These steps will provide an opportunity to some of the developed countries to push their sizeable farm subsidies under non-actionable group putting forth the biofuel front. Third, the debate may emerge in the context of technical barriers to trade as the technologies are well developed by a few countries. Lastly, the biofuel sector may also cause a flutter in the context of the neglected interface between environmental agreements (Kyoto Protocol) and WTO. The declaration of the agreement on South Asian Free Trade Area (SAFTA) gives both hopes and aspirations for added efficient cooperation in the promotion of biofuels. In short, a well-conceived biofuel programme with effective cooperation among the countries has the potential to lead South Asia to high rates of energy sustainability.

Sources and Preference for Biofuels

In the South Asian countries there are significant variations in the composition of the energy mix. More than 90 per cent of the South Asian energy demand is from fossil fuels.[1] In this, petroleum accounts for more than 34 per cent. More than 70 per cent of the oil demand is met through import and the quantum of imported petroleum is projected to be double by 2020. In this context Biofuel is seen as an alternative to petroleum energy which can play a significant role. Biofuel is an ester-based fuel oxygenate derived from renewable bio-resources such as *Pongemia Pennata*; *Jatropha curcas*, soybean, mustard, rapeseed, peanuts, palm oil, other vegetable oils, and animal waste like beef tallow.[2] It can be used in pure form but not advised accordingly due to the problem of *polymerisation* (vegetable oils contain triglycerides that end up in high oil gumminess resulting in formation of long saturated carbon chains) and therefore largely blended with petroleum diesel (petrodiesel) for use in compression-ignition (diesel) engines.[3]

Non-edible oil as biodiesel provides a win-win proposition for the densely populated Asian countries. Perennials such as *Pongamia* pinnata and *Jatropha Curcas* have offered an excellent opportunity to remedy the problems of environmental protection and oil crisis. Strategies for rehabilitating degraded lands and improving livelihoods through biodiesel plantations based on field experiences offer good potential.

Biofuel Promotion in Asia

Among Asian countries, Thailand is tapping the potential of tapioca, cassava and palm oil, while in Indonesia both Palm oil and *Jatropha* are being tapped. In India thrust is on *Jatropha Curcas*, which can be grown in both arid and semi arid regions. High oil prices volatility and inconsistency in oil supply in the last decade have resulted in the increased awareness in major energy consuming Asian countries to look for an alternative that is indigenous and is sustainable. Already there are major players from the EU and US looking at vast lands of Asia and Africa as a potential gold mine of opportunity. European Union Biofuels Directive (2003/30/EC) lays down guidelines to expand the production and use of biofuels derived from agricultural, forestry and organic waste products. The directive sets only indicative targets and not mandatoray targets. The target for 2005 is 2 per cent of transportation fuel and 5.75 per cent by 2010. Thus as per the biofuels directive, member states should ensure that a minimum proportion of biofuels and other renewable fuels is placed on their market. If the objectives set in the directive are achieved, the consumption of biofuels in the EU will increase from 1.4 milliion tons oil equivalents in 2001 to 19 million tons in 2010.

The Energy tax directive (2003/96/EC, 27.10.2003), gives the possibility to member states to grant tax reductions/exemptions in favour of biofuels, under certain strict conditions. The exemption or reduction in taxation applied by member states must be adjusted to take account of changes in raw material prices to avoid over-compensation. In turn most of the Asian countries are in the process of putting policies and legal mandates in place to have a viable and mandatory fuel mix with bioenergy (see Table 1).

Many Asian countries like Philippines, Thailand, Indonesia, Japan and China have initiated the bio-diesel programme but they all are at different stages of development. The Philippines has launched the Coco-biodiesel (a form of biodiesel known as Coco Methyl Ester or CME) programme, which is a derivative of coconut oil. Thailand is fast developing gasohol, a blend of gasoline and plant-based ethanol. But the bio-diesel initiative in Thailand is still in experimental stages. Malaysia, which is the world's largest producer of palm oil, is moving towards the direction of taking a set of initiatives for promoting the use of palm bio-diesel. The government unveiled a National Bio-fuel Policy in August 2005. Indonesia, the world's second-largest palm oil producer, is preparing a biofuel scheme for the next five years.[4] Indonesia aims to boost crop area under palm plantations to 8 million hectares in the next three years from the current 5 million hectares. Indonesia is exploring the world biodiesel market as world palm oil demand stagnates.[5] Though China ranks third in the world in ethanol production, not much of it is used as fuel. The Chinese bio-ethanol fuel programmes are a product of State sponsored five-year plans.[6]

Table 1. Promotion of Biofuels in Asia

Country	Source of Biofuel	Suggested Percentage of blending	Year of National Biofuel Policy or Act issued
China	Ethanol	10	2005
India	Ethanol, *Jatropha* oil and Pongemia Oil	5*	2003
Japan	Ethanol	3	2003
Malaysia	Palm oil	5	2005
Thailand	Topioca and Ethanol	10	2005
The Phillippines	Coconut oil	10	2005

Note: * Some bulk users, like public transport corporations are using up to 10 per cent and planning to use up to 20 per cent.
Source: Prepared by the author.

Though new ethanol plants are under construction, projections show that the demand for ethanol required for a 10 percent blend for all cars in China would far exceed the projected supply even after taking into account all the present proposed initiatives.[7] At the same time biodiesel production in China is still at a very nascent stage.

In South Asia much of the ethanol production comes from India and Pakistan. Use of alcohol as a fuel becomes significant option in these countries very recently. In Bangladesh, at present LPG are making inroads and biofuels have yet to make an impact. Private companies are making plans to manufacture fuel alcohol in the country. An investment of $4.5 million will be made for a 12000litres/day ethanol plant, which uses molasses as a feedstock (Bangladesh Observer, 2005).

Biodiesel programme in India is in the formative years of development. Both the Central and State governments are keen to push the biodiesel programme considering the benefits of large scale rural employment and sustainable energy sources. At the Central governmental level biodiesel programme started in 2003 when the Committee on Development of Bio-fuel (Planning Commission) recommended launching of a National Mission on Bio-diesel.[8] The special focus of the National Mission was on plantation of *Jatropha* on wastelands. In August 2003 Ministry of Rural Development (MoRD) was identified as the nodal ministry and in January 2005 a Detailed Project Report was prepared with extensive consultations for the pilot phase (*Jatropha* plantations on 400,000 ha). The government of India announced the Biodiesel Purchase Policy in 2005 and implemented National Mission on Biodiesel in 2006. The major step forward in the Indian ethanol programme was the Government of India notification on EBP (Ethanol Blending Programme). This notification made five per cent ethanol doping in petrol mandatory in nine states and four territories, with effect from 1 January 2003. At the State government level, several States have initiated biodiesel programmes and policies.

States like Chattisgarh, Uttaranchal, Rajasthan, Andhra Pradesh and Tamil Nadu have already formed nodal agencies for bio-diesel development and announced draft bio-diesel policies. These states have initiated plantation programmes as well.

There is a need to work out a legal regime supporting biofuel initiatives. This would provide a legal mandate for the compulsory blending of biofuels with regular fuels. To facilitate the entry of more players in the biofuel industry and to ensure the uninterrupted supply of biofuels, the production of the same should be made economically viable. Thus the law should also provide for various tax breaks and subsidies. Once the biofuel industry attains the economies of scale to be self-sustaining, these incentives can be gradually withdrawn.

Future Challenges

Although technologies, policy support, and demand for biodiesel are building up, the main constraint is supply of raw material. Validated and good quality data on agronomic practices, yield potential, diseases and pest management, and water requirement are not available. Many failures of planting programmes have been attributed to the selection of inappropriate species, varieties and climatic condition. Therefore choice of appropriate species plays a key role in such programmes, which is governed by a full understanding of the climatic and edaphic factors among others. Extensive research programmes also need to be implemented to channelise inexpensive alternate feedstocks for biofuel production. There is an urgent need to undertake research on all aspects of biodiesel plantations along with legislative framework.

There is also a need to enhance production and supply of *Jatropha* and *Pongamia* and other non-edible oils to be used as biodiesel. The proposed strategy is to bring vast areas of degraded and low quality lands under biodiesel plantations. The total number of species with oleaginous seed material mentioned from different sources varies from 100 to 300 and of them 63 belonging to 30 plant families holds promise.[9] Two species namely *Jatrohpa curcas* and *Pogamia pinnata* are favoured in Indian context because of their contrasting plant characteristics.

Further more, the respective governments may undertake identification of existing resources and country specific feedstocks, which can be channelized for biofuel production. Depending on the climate and soil conditions, different countries should look for suitable types of vegetable oils. Import of full-fledged technology from other countries is also a good option, but this should be coupled with indigenous technological interventions.

Biodiesel plantations can be successfully utilized in order to improve livelihoods on sustainable basis. It has also the potential for generating the employment from plantation, harvest and processing activities, which will reduce migration from rural areas. Participation of women Self-Help-Groups (SHGs) in managing the plantations will boost their livelihoods and will empower the women. Biodiesel plantation provides win-win situation to protecting environment, increased income, and generating employment opportunities in rural areas. And South Asian countries have enormous potential for biofuels and have complementary endowment on a contiguous landmass, which can help tremendously in developing an integrated bioenergy framework. Incredibly organized planning and intense research efforts are two key components for the implementation of a sustainable biofuels programme. As land requirement emerges as a major prerequisite in the biodiesel programme, there should be proper identification programmes for wasteland and documentation of marginally productive and wastelands, which can be targeted for plantation of oil bearing plant species, without compromising on food production.

Policy Measures

- One of the options for promoting livelihoods of poor is through promotion of plantation by user groups or SHGs on common pool lands like degraded forests, community owned lands, low quality lands not suitable for annual food crops production, railway setbacks, canal embankments, tank foreshore, etc.
- There is need to have a strategy to develop/rehabilitate degraded lands through biodiesel plantations by efficient use of existing natural resources.
- Lack of scientific information about suitable management practices as well as identification of high-yielding accessions and lack of high yielding cultivars on large scale holds back development in this area. There is an urgent need to undertake detailed research for development of management practices, high-yielding cultivars, mass multiplication techniques, suitable development models for increasing supply of raw material for bio-diesel production.
- There is need to promote decentralised extraction and decentralised processing. Asian countries should promote and utilize the expellers available locally as it will minimize the cost of transport of raw material, and will generate employment in rural areas. There is a possibility of using oil directly in the irrigation pumpsets and can be blended directly with diesel up 10 per cent for use in farm machinery.
- Recycling of cake for production of biogas and compost. The cake offers an excellent opportunity for reducing the dependence on fertilizers and its marketing will generate additional income. The cake can also be used for production of biogas before composting

and both these two processes will improve nutrient availability to the crops and will reduce pressure on energy demand for domestic use.

- Biofuel plantations can earn carbon credits. Powerguda, a remote tribal hamlet in the Adilabad district of Andhra Pradesh in India, became an environmental pioneer when it sold the equivalent of 147 tons of carbon dioxide in verified emission reduction as carbon replacement to the World Bank in October 2003. The World Bank paid US $ 645 to Powerguda women SHGs to neutralize the emissions from air travel and local transport by international participants attending its international conference in Washington, USA held on 19-21 October 2003.
- Employment generation from plantation, harvest and processing activities will reduce migration from rural areas, which is a big concern in most Asian countries. Participation of women SHGs in managing the plantations will boost their livelihoods and will empower the women.
- It has both tangible benefits as well as in-tangible benefits. There are innumerable in-tangible benefits like: a) potential to produce a green fuel that will reduce carbon dioxide emissions and re-circulating atmospheric CO_2 through the process of photosynthesis; b) greening of waste and marginal lands, which has positive impact on hydrology; c) alleviate soil degradation, deforestation and conserve soil and rainwater; and d) improved ecosystem and environmental sustainability.

This volume

This Special Volume on Biofuels has five papers. Each paper has dealt with a specific issue related to Biofuels to indicate the emerging trends in South Asia. The paper by Suhas Wani, Osman, D'Silva and Sreedevi has focused on how rural livelihoods and biodiesel plantations in Asia can enhance environmental protection. From macro perspective, Rammohan and Thomas Phillippe have explored a legal framework to support biofuels which can be used as an instrument for energy access and security as part of the environment protection and rural empowerment in South Asia. Linoj Kumar, Prabha Dhavala and Sameet Maithel argue how resources and technologies can play a vital role in promoting biofuels in South Asia in their paper on Liquid Biofuels in South Asia. Equally important is whether WTO agreements have any implications on promotion and use of biofuels in Asian region. This has been discussed threadbare by Despande. I hope this special Volume would enable to generate more comphrensive dialogue on these issues, which would help to clear the clouds and promote use of biofuels.

Endnotes

[1] Hussain Leelaratne and Razaak 2002.

[2] Biodiesel is a one of the main components of biofuels. It was introduced in a few countries around World War II, to power vehicles and the interest was renewed in the recent past, now it is partially replacing the traditional fuel.

[3] EIA, 2001.

[4] http://www.planetark.com/dailynewsstory.cfm/newsid/33161/story.htm

[5] http://www.planetark.com/dailynewsstory.cfm/newsid/31182/story.htm

[6] Moore, Janet 2005 http://www.startribune.com/117/story/73696.html

[7] Slingerland and Geuns 2005.

[8] Report of the Committee on Development of Biofuels, Planning Commission 2003.

[9] Hegde, 2003.

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Improved Livelihoods and Environmental Protection through Biodiesel Plantations in Asia

Suhas P. Wani*, M. Osman, Emmanuel D'Silva, and T.K. Sreedevi

Abstract: Increasing energy demand and spiraling oil prices are the cause of financial strain on countries and also causing environmental degradation. Use of non-edible oil as biodiesel provides a win-win proposition for the densely populated Asian countries. Perennials such as *Pongamia pinnata* and *Jatropha curcas* have offered an excellent opportunity to remedy the problems of environmental protection and oil crisis. Strategies for rehabilitating degraded lands and improving livelihoods through biodiesel plantations based on field experiences are discussed.

Although technology, policy support, and the demand for biodiesel are increasing, the main constraint is supply of raw material. Validated and good quality data on agronomic practices, yield potential, diseases and pests occurrence, water requirement and management for block plantations are not available. There is an urgent need to undertake research on all aspects of biodiesel plantations.

Introduction

Energy security has assumed a greater significance than ever before as energy consumption, food production, improved livelihoods and environmental quality are interrelated. Asian countries with dense population are more prone to energy crises than are their counterparts in the developed world. A strong nexus between energy use for irrigation water and agricultural output exists. The number of borewells in India and energy consumption have increased dramatically over the last two decades. Groundwater now sustains almost 60 per cent of the India's irrigated area. Even more importantly, groundwater now contributes more to agricultural wealth creation than any other irrigation source.[1] During a recent study undertaken by ICRISAT in Rajasamadhiyala

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watershed in Gujarat it was noted that not only had the number of open and bore wells in a village of 1000 ha increased from 357 to 508 within eight years but pumping hours had also increased from 5.25 to 10.4 hours per day, putting pressure both on energy resources and groundwater.[2] In addition, farmers also keep additional diesel pumpsets as a stand by to cope with the prevailing power cuts. Agriculture is now more dependent on mechanical and electrical sources of energy than on human and animal power. During 1988-89 to 2004-05, farm power availability in Anantapur village, a predominantly dryland area increased by 28 per cent, while mechanical power use increased remarkably by 730 per cent.[3]

Any increase in food production calls for higher energy use in terms of irrigation and fertilizer, as further expansion of area under agriculture is limited. Areas that are left fallow or degraded and not fit for agriculture offer an opportunity for 'greening' through tree-based oilseeds (TBOs). The advantages of perennials are many for example, greenery will protect the land from further degradation and generate employment in rural areas. The total number of species with oleaginous seed material mentioned from different sources varies from 100 to 300 and of these 63 belonging to 30 plant families hold promise.[4] Two species namely, *Jatrohpa curcas* and *Pogamia pinnata* are favoured in India because of their contrasting plant characteristics and the species selected should match the site characteristics (see Table 1).

Jatropha is highly drought tolerant and is well suited to semi-arid conditions although it thrives in arid areas. It occurs mainly at lower altitudes (0-500m) in areas with an average annual temperature well above 20 °C but can grow at higher altitudes, tolerates slight frost, and up to 1000 mm rainfall.[5] *Pongamia* thrives well up to 1200 m altitude and rainfall of 500-2500 mm per annum. *Pongamia* withstands temperature from about –1°C to 50°C. Both plants can withstand drought but *Jatropha* sheds its leaves during the dry period (summer) while *Pongamia* retains leaves and is evergreen. Gall formation on leaves caused by mite in *Pongamia* is a major concern as it affects leaf area/ photosynthesis and it is widespread. *Jatropha* has an affinity for well-drained soils and is susceptible to collar rot disease in high rainfall humid areas or excessive irrigation or water logging conditions, while *Pongamia* can tolerate water logging, saline and alkaline conditions. Both the species are suitable for semi-arid tropics and are not grazed or browsed by livestock.

Table 1: *Jatropha vis-à-vis Pongamia*

Characteristics	*Jatropha curcas*	*Pongamia pinnata*
Ecosystem	Arid to semi-arid, up to 500 m altitude	Semi-arid to sub-humid, up to 1200 m altitude
Rainfall	Low to medium up to 1000 mm	Medium to high up to 2500 mm
Soil	Well drained soils	Tolerant to water logging, saline and alkaline soils
Nitrogen fixation	Non fixer	N_2 - fixing
Plant suitability	Wastelands, degraded lands, live fence for arable lands, green capping of bunds, shallow soils	Field boundary, river and stream banks stabilization, wastelands, tank foreshore
Plant habit	Mostly bush, can be trained as small tree	Tree can be managed as bush by repeated pruning but will affect yield
Leaves	Not palatable by livestock	Not palatable by livestock, used as green leaf mulch
Gestation period	Short, 3rd year	Long, 7th year
Yield	1.0 kg/plant	10 to 200 kg/tree
Oil content	27-38% in seed	27-39% in kernel
Protein	38%	30-40%
Fire wood	Not useful	Good as firewood, high calorific value 4600 k cal/kg

Source: ICRISAT, 2005 unpublished data; Parmathma *et.al.*, 2004.

i) *Seedling Management*

Tree improvement programmes have mainly concentrated on a few plants like *Eucalyptus spp.* and Poplar (*Populus deltoides*) but no systematic efforts have been made in the past to improve tree borne oilseeds like *Pongamia* and *Jatropha.* As the genotype and the environment influences yield, therefore, the source of seed assumes greater significance. The quality of the seedlings also affects survival, growth as well as yield and this is further dependent on media and propagation technique.

Variability in Seed Sources

It is desirable to select the seed source for multiplication from known plant populations with favourable traits. However, no systematic efforts have been made to evaluate and document the existing variability in seed sources of both the plants. Since the last 2-3 years, a few researchers have started collecting seeds from high yielding trees of *Pongamia* and *Jatropha.* A preliminary study conducted at ICRISAT for samples collected in the states of India by various researchers and suppliers indicates great

Table 2: Evaluation of Seed Samples of *Jatropha* and *Pongamia* for Oil content, Test Weight and per cent Germination

Sl. No.	Collection No.	Place of collection	100 seed weight (g)	% Oil content	Germination %
Jatropha					
1	IJC-1	Rajgarh	63.8	28.0	10
2	IJC-2	AP	68.2	38.4	90
3	IJC-3	Tamilnadu (cape viridi type)	49.2	29.9	61
4	IJC-4	Tamilnadu (Erode local)	44.0	28.6	85
5	IJC-5	Tamilnadu (wild collection)	77.2	29.3	50
6	IJC-6	Rajasthan	69.5	34.8	78
7	IJC-7	Rajasthan	51.3	29.3	51
8	IJC-8	JNKV	72.6	34.7	-
9	IJC-9	CHRK-VSP	67.3	32.8	70
10	IJC-10	MONDC	69.2	31.8	-
11	IJC-11	CHRK-GBR	69.4	34.4	17
12	IJC-12	TFRI	66.5	33.5	-
13	IJC-13	Rajasthan	57.6	34.4	30
14	IJC-14	-do-	53.2	27.8	23
15	IJC-15	-do-	60.67	33.6	42
Pongamia					
1	P-1	Mumbai	233.2	30.4	90
2	P-2	Goa	132.7	21.3	90
3	P-3	Orissa	155.0	33.5	90
4	P-4	Bangalore	177.0	40.9	90
5	P-5	Adilabad	102.4	39.5	90
6	P-6	Adilabad (Behranguda)	105.2	32.9	90
7	P-7	Gurgaon	101.0	34.5	85
8	P-8	-do-	101.5	33.3	85
9	P-9	-do-	101.2	36.6	85
10	P-10	-do-	102.0	33.1	85

Source: ICRISAT, 2005 unpublished data.

variability in terms of *Jatropha* and *Pongamia* oil content; 100 seed weight and per cent germination (see Table 2). The seed source of *Jatropha* IJC-2 and IJC-6 were found to be promising in terms of oil content.

Nursery Techniques

There are several propagation techniques like direct seeding, cuttings, and nursery raising, which are discussed in detail below.

1. *Direct seeding:* One to two seeds of *Jatropha* and *Pongamia* can be sown directly in the ploughed and marked field. The main field should be ploughed and spots may be marked and enriched with FYM receiving the seeds. Twenty gram urea, 120 g single super phosphate and 60 g muriate of potash should be applied after establishment of the plant. Seedlings grown by this method will take time for establishment and

will have slow growth in the initial period. However, there should be enough moisture in the soil to support germination and seedling growth. Frequent weeding is required to prevent the seedlings from competing weeds and shade. Similarly, soil working around the seedlings will boost the growth and will improve the moisture and rainfall infiltration. *Pongamia* seedlings grown this way can be *in-situ* grafted with a scion from high yielding tree after nine months.

2. *Vegetative propagation (transplanting of pre-rooted cuttings/grafting): Jatropha* can be multiplied by raising the cuttings on a raised bed and can be later transplanted into the main field. Multiplication of *Pongamia* by cuttings is difficult but grafting is easier. Cuttings of 2-3 cm thickness from the lower portion of the shoot and of 25-30 cm length may be prepared in the month of March, when plants shed most of their leaves. These cuttings are planted in nursery beds at a spacing of 30x30 cm or in polybags. Pre-treatment of stem cuttings with 300 ppm IBA (Indole butyric acid) solution for 5 minutes is desirable. Sprouting starts within 7 days of planting. Plants propagated by cuttings will normally produce seeds within a year of planting and growth is rapid. However, it has been observed that seedlings raised from seeds have a better root system compared to pre-rooted cuttings, which develop secondary and tertiary fine roots. Such seedlings are more stable during storms. The plants raised through cuttings will be true to type and will have similar characteristics of the mother plant. To maintain the quality of plantations of *Pongamia*, there is a possiblity of *in-situ* grafting. The rootstock may be raised directly by seeding in the pits (two to three seeds). The desirable scion material may be grafted on the rootstock when the seedlings attain pencil thickness. The technique needs to be standardized for *Pongamia* as followed in mango.

3. *Nursery raising: Jatropha* plant can be grown by two methods, namely bare root and container method (polythene bag). In the bare root method, nursery bed is prepared by mixing FYM, soil and sand in equal volumes. Soaked seeds are sown at a row spacing of 25 cm and a plant to plant distance of 5cm. The plants will be ready for transplantation in the main field six weeks after germination. The plants may be carefully uprooted from the nursery beds, wrapped in wet gunny bag and transported to the main field. Uprooted seedlings may be transplanted within 24 hrs. Before transplanting it should be ensured that enough moisture is available in the pit receiving the bare root seedlings. Bare root seedling production of *Pongamia* is difficult as it

has a tap root system and will get disturbed during lifting from nursery beds. Seedlings of both *Jatropha* and *Pongamia* can be grown in poly bags of mostly black colour (4" x 7", 150 gauge for 3-4 months old seedlings). The bags may be filled with equal parts of soil, sand and FYM (1/3, 1/3, 1/3). 1.0 g per polybag of Diammonium phosphate (DAP) may be added to 2 kg soil weight. Good quality seeds having 80 per cent germination should be sown with one seed per bag at 2-3 cm depth for getting higher per cent germination. One gram of mycorrhizae (mixed culture) may be placed below the seed at the time of sowing to enhance growth of seedlings. *Jatropha* seedlings treated with mycorrhizae in unsterlized soil + FYM mixture had higher plant height, girth and number of leaves compared to control, when sampled 85 days after sowing (see Table 3). Similarly, treatment of *Pongamia* seeds with *Rhizobium* and mycorrhizae, *Azatobacter* was found promising for improving seedling growth. *Pongamia* seedlings treated with *Rhizobium* and *Azatobacter* had a higher number of nodules, shoot and root weight when sampled 85 days after sowing (see Table 4). Grading and root pruning is suggested to promote uniform growth of seedlings.

ii) *Field Management*

Genotype and the environment (field condition) influence the survival and growth of the seedlings. There are several steps involved in

Table 3: Effect of Mycorrhizal Inoculation on Growth of *Jatropha* Seedlings in Nursery

Treatment	Plant height (cm)	Stem girth (cm)	Number of leaves
Inoculated	47	6.5	16
Non-inoculated (control)	35	5.9	12

Source: ICRISAT, 2005 unpublished data.

Table 4: Effect of *Rhizobium* and Mycorrhizal Inoculation on Nodulation and Biomass of *Pongamia* Seedlings in Nursery

Treatment	Nodule number/ seedling	Fresh weight (g/seedling)		Dry weight (g/seedling)	
		Shoot	Root	Shoot	Root
No treatment (Control)	11	5.5	5.0	1.2	1.3
Rhizobium alone	19	6.0	5.4	1.3	1.8
Mycorrhizae alone	12	5.8	5.9	1.3	1.5
Mycorrhizae + *Rhizobium*	17	6.2	7.9	2.3	1.9
Mean	15	5.9	6.0	1.5	1.6
LSD ($P \leq 0.05$)	1.8	2.4	2.0	0.98	0.69

Source: ICRISAT, 2005 unpublished data.

management of the field. First, the field may be ploughed (deep tilled) followed by harrowing at the beginning of the rainy season or by utilizing off-season rains. Direct planting may be taken up in dug out pits in hilly and rocky areas where cultivation is not possible.

A spacing of 3m x 2m or 3m x 3m spacing is desirable for intercropping and intercultivation. For hedgerow/ boundary plantation of fields, the spacing should be 1 m x 1 m. For *Pongamia* block-planting, a spacing of 5m x 5m or 6m x 6m is suggested. For avenue and field boundary planting, a spacing of 2m to 4m may be given from plant to plant. Mixed planting of *Jatropha* and *Pongamia* and alignment of rows in the east-west direction is suggested. A spacing of 6m x6m for *Pongamia* and 3m x3m for *Jatropha* is desirable. The recommended size of the pit is 30 cm x 30 cm x 30 cm for *Jatropha* and 45cm x 45cm x 45cm for *Pongamia*. The pits may be dug well in advance of planting time. Refilling of the pits may be done by mixing 1.0 to 2 kg of FYM, 50 g of DAP and methyl parathion (2 per cent dust) @ 5 to 10g or 5g of thimmet granules per pit may be applied to protect the young saplings from termites' damage.

Transplanting

Seedlings having a plant height of 60 cm may be transplanted with the on-set of rainy season and the soil around the seedlings should be compacted. Normally, *Jatropha* attains a height of 60 cm in 60 to 75 days while *Pongamia* takes little longer time 90-105 days. The survival percentage will be more in case of plantation raised by seedlings compared to direct seeding. Seedlings are susceptible to competition from weeds in the first year. Therefore, weed control either manual or by herbicide is required during the establishment phase.

Irrigation and Moisture Conservation

Although *Jatropha* and *Pongamia* are hardy plants, even then they require adequate moisture in the root zone during the initial period. Irrigation once in a month during the dry period will be quite beneficial for enhancing growth and productivity. Rain water conservation techniques like planting on contour or staggered trenches will be advantageous in hilly, slopy and rocky areas where intercultivation and intercropping is not possible. Making ring basins around the plants and mulching (dust mulch/organic mulch) will conserve soil moisture and minimize irrigation needs. Tree loppings and straw is ideal for conserving the soil moisture in the basins. Creating surface roughness by intercultivation, etc. will enhance rainwater conservation and use. Irrigation needs vary with local soil and climatic conditions and need to be standardized. *Jatropha* can stand long periods of drought by shedding leaves while *Pongamia* remains green during dry periods. Irrigation during dry periods at fortnightly intervals during first year is suggested to improve growth and yield, if available. However, with appropriate soil moisture conservation techniques, *Jatropha* and *Pongamia* plantations in degraded common lands in Andhra Pradesh, Madhya Pradesh and Rajasthan showed 70 – 75 per cent survival after one year without any irrigation.

Manures and Fertilizers

It is often said that *Jatropha* and *Pongamia* do not need any nutrition. The plants may survive in soil having poor fertility but seed production will be very poor and will have only foliage. There are no systematic studies conducted on the nutritional requirement for *Jatropha* and *Pongamia* block plantations. However, based on experience with other plantations it may be seen that organic manures (FYM/Vermicompost) @ 1 kg/plant for *Jatropha* and 2 kg/plant for *Pongamia* and a fertilizer dose of 50 g of DAP for *Jatropha* and 100 g of DAP for *Pongamia* in the first year need to be applied at the time of filling the pits. In subsequent years, top dressing of *Jatropha* @ 50g and 100g of urea and SSP per plant, respectively while for *Pongamia* DAP @100g per plant is suggested. Alternatively, oil cakes can be recycled in these plants to maintain the productivity of soil. The plants respond well to addition of small quantities of calcium, magnesium and sulphur. Mycorrhizal associations have been observed in *Jatropha* and they are known to aid the plant growth under conditions where phosphorus availability is low.

Weeding

The basin should be kept free from weeds. Hoeing and weeding is essential during the establishment period. Around 2-3 weedings/intercultivations are enough to keep the field free from weeds and conserve moisture.

Irrigation

Jatropha was found to respond to irrigation and was also recommended by the growers.[6] Similarly, a field study in Nalgonda, revealed that *Pongamia* too has a liking for water and fertile soils. *Pongamia* grows mostly along the watercourses like streams and waterways,[7] while traditionally it is grown on field and farm bunds particularly around paddy fields.

Canopy Management

The flowering occurs at the terminal portion of the branches in *Jatropha* and along the branches in case of *Pongamia*. Therefore, efforts should be made to train and prune the plant in such a way that the number of fruiting branches increase. In *Jatropha*, the terminal bud should be nipped to induce secondary branches. Likewise the secondary and tertiary branches are to be pinched or pruned at the end of first year to induce a minimum of twenty-five branches at the end of second year.[8] Once in ten years *Jatropha* may be cut back leaving a one-foot height from the ground level for rejuvenation. The growth is quick and the plant starts yielding in about a years period. This will be useful to induce new growth and to stabilize yield. In a study of canopy management in North East Thailand, the cutting of *Jatropha* at a height of 50cm from the bottom was found reasonable to maintain a compact bush form. The end of the dry season was found to be the optimum time for cutting back as the plants go in dormancy after the fruiting season. Thinning twice after one and two months of cut back was recommended to promote useful fruiting branches and to maintain a compact bush form.[9]

The *Pongamia* plants may be pruned initially to give the stem a straight form and later lightly lopped for green leaf mulch. All the side branches of tree, one third from the bottom may be pruned and the top two third branches on the plant may be retained. Periodical pruning can be carried out depending upon the vegetative growth of the plants. The pruning should be done when trees shed leaves and enter into a period of dormancy. Diseased, dead, excessive, weak and lateral branches should be removed.

Insect Pests

In the case of *Jatropha*, insects such as leaf eating beetles, thrips, leaf hoppers, grass hoppers, caterpillars and leaf miner will feed on foliage. Shoot/stem borer and bark eating caterpillar will damage the stem. Blue bugs and green stink bug will be sucking on fruits while capsule borer will damage the fruits.[10] In the case of *Pongamia*, leaf miner, leaf galls, bark eating caterpillar and other pests are found. The pest may be controlled by spraying Endosulfan @ 3 ml per litre of water or any other pesticide recommended for that particular pest. The galls are formed due to the attack of mites and can be controlled by spraying Dicofol @ 5 ml per litre of water or wettable sulphur @ 3 g per litre of water.

Diseases

In case of *Jatropha*, collar rot may become a problem in some areas in monoculture plantations under irrigated condition. It is severe under water logging conditions and excess soil moisture. The rot can be controlled by drenching with 1 per cent Bordeaux mixture. Minor diseases such as root rot, damping off, powdery mildew and leaf spots are reported.[11] There is no specific mention of diseases in case of *Pongamia*.

Harvesting

The flowering in *Jatropha* depends upon the location and agroclimatic conditions. Generally it takes place from August to December in India. However, this flowering and fruiting depends on the site, soil moisture and climatic conditions. Fruits mature within two to four months after flowering. The ripe fruits should be harvested/plucked when it reaches physiological maturity (yellow capsule stage). There is no synchronized flowering and fruiting, which makes harvesting a labour intensive process. *Pongamia* flowers once in a year and takes about 8 to 10 months to mature. Pods can be easily harvested/collected after leaf shedding and before the new flush comes by shaking the branches. Rural women and unemployed youth can be gainfully employed for collection and will improve their livelihoods.

Processing and Handling

After collection the fruits are transported in open bags to the processing site. They are dried till all the fruits are opened and decorticated manually or by decorticators. It has been reported that direct sun drying has a negative effect on seed viability and the seeds should be dried in the shade.

Yield Potential

Jatropha plant begins bearing from first year onwards and stabilizes from the fifth year. It gives an economic yield up to 30-40 years. The expected yield from one-hectare plantation is near about 750-1500 kg under rainfed and 1500-2500 kg under irrigated conditions. *Pongamia* starts bearing at the age of 7 years. A single tree yields 10–200 kg seed, indicating a minimum yield potential of 1000kg/ha; however, grafted seedlings start bearing from the third year. Irregular bearing has been noticed in *Pongamia* and the yield may vary from year to year. However, no systematic data on yield from block plantations are available. In Maharashtra, where block plantations on *Jatropha* were undertaken in the 1980s without irrigation, a yield of 1000–1200 kg ha^{-1} was recorded.[12]

There is an urgent need to study the yield potential of both the plants with appropriate agronomic management practices in block plantations.

Storage and Viability

The seeds should be dried to reduce the moisture content (5-7 per cent) and stored in cool and dry place. At room temperature the seeds can retain high viability for at least one year. However, because of the high oil content the seeds cannot be expected to store for long time.. Oil can be extracted using low cost expellers in the village itself and oilcake may be retained with the growers/ collectors for application to fields as an organic fertilizer or can be sold to prospective buyers.

iii) *By-Product: Oil Cakes as Source of Plant Nutrients*

Oilcake a by-product after extraction of oil appears to be a very attractive proposition as it contains all the macro and micro-nutrients and it is an excellent organic fertilizer unlike inorganic fertilizers that supply only few nutrients. Four kilograms of seed of *Pongamia* or *Jatropha* give about three kilograms of cake. The cake is mostly used for fertilizing plantation or commercial crops. An analysis of the contents of the cake of *Pongamia* and *Jatropha* indicated the presence of all the essential elements required for plant growth, particularly found to be rich in nitrogen and sulphur (see Table 5). Recycling of *Pongamia* cake in Adilabad district of Andhra Pradesh resulted in a 41-47 per cent increased income when compared to farmer's practice (see Table 6).

Table 5: Chemical Composition of Oilcakes analyzed at ICRISAT, Patancheru, India

Nutrients	*Jatropha*[1]	*Pongamia*[2]	*Pongamia*[3]
Nitrogen (%)	4.91	4.28	6.14
Phosphorous (%)	0.90	0.40	0.72
Potassium (%)	1.75	0.74	1.07
Calcium (%)	0.31	0.25	0.96
Magnesium (%)	0.68	0.17	0.35
Zinc (ppm)	55	59	95
Iron (ppm)	772	1000	1053
Copper (ppm)	22	22	41
Manganese (ppm)	85	74	108
Boron (ppm)	20	19	43
Sulphur (ppm)	2433	1894	3615

Notes: Source of oilcake: [1] Coimbatore, Tamil Nadu.
[2] Adilabad, Andhra Pardesh.
[3] Tumkur, Karnataka.
* DAP = Diammoium phosphate.
Source: ICRISAT, 2005 unpublished data.

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Table 6: Response of Soybean and Maize to the Application of *Pongamia* Cake and Inorganic Fertilizers

Crop	Treatment	Yield (kg ha^{-1})	Income (Rs. ha^{-1})	Cost of fertilizer (Rs.)	Additional income over farmer'spractice (Rs.ha^{-1})
Soybean	Farmer's practice (DAP 75 kg ha^{-1})	900	10800	450	-
	Pongamia cake (PC) (300 kg ha^{-1})	1340	16080	1500	4230
	Recommended dose of fertilizer (RDF) 20 kg N ha^{-1}	1450	17400	250	6800
	50% RDF + 50% PC	1650	19800	1500	7950
Maize	Farmer's practice (DAP 125 kg ha^{-1})	1200	6000	1125	-
	Pongamia cake (PC) (1800 kg ha^{-1})	2240	11200	4000	2325
	Recommended dose of fertilizer (RDF) 90 kg N ha^{-1}	2390	11950	1000	6075
	50% RDF + 50% PC	2560	12800	5000	2925

Source: Source: ICRISAT, 2004 unpublished data.

Similar studies carried out by Ngoma (1999) in Zimbabwe have revealed that application of *Jatoropha* cake at the rate of 0, 0.25, 0.5 and 1.0 kg/sq. m resulted in cabbage yields of 16.8, 23.6, 22.8 and 35.8 kg, respectively and the crop was free from pest and diseases. Tasosa *et. al.* (2001) have recorded a significant difference in the growth rates of tomato and the total above ground dry matter with increased application rates of *Jatropha* and castor cakes. Henning (2000) is of the opinion that *Jatropha* plants can reduce the soil and water erosion when planted as live fence and the cake obtained after oil extraction can help in building the organic matter content of the soils of Sahelian countries. Substitution of oilcakes with fertilizers is likely to improve the fertility of the soils in the long run and the soils will overcome the widely observed deficiency of several nutrients like N, P, Zinc, Boron, Sulphur, etc. Further, it will reduce the dependence of farmers on external input (fertilizers). Recycling of the cake serves the interest of farmers as well as of the government as the huge subsidy paid on fertilizers to industries can be reduced. The amount saved on subsidy of fertilizers can be used for encouraging biodiesel plantations in rural areas for ensuring energy, food and livelihood security.

iv) *Plantation Management – Strategies for Livelihoods Enhancement*

In the semi-arid tropical region, large numbers of poor people reside and most of them are landless and marginal small landholders. Biodiesel plantations could be successfully utilized to improve livelihoods on a sustainable basis and to rehabilitate the degraded lands and protect/ improve the environment.[13] There is already a good market demand globally for biodiesel with spiraling fossil fuel prices and the increased awareness of the adverse impact of global warming. Good policy support from the national governments also exists, e.g. in India and Thailand where governments have extended good support for enhancing production and use of biodiesel. Technological options to process biodiesel using multi-feed stocks also exist. However, the missing factor or the fourth wheel to run the biodiesel car is an assured supply of raw materials.[14] There is an urgent need to enhance production and supply of *Jatropha* and *Pongamia* and other non-edible oils to be used as biodiesel. In densely populated countries of Asia as in Europe edible oils cannot be used for biodiesel production as already these countries are in short supply of edible oils for human consumption. Similarly, to achieve oil security most of the developing countries would not like to sacrifice their food security. The proposed strategy is to bring vast areas of degraded and low quality lands under biodiesel plantations.

Collector's Model

In many Asian countries already a large number oilseed trees exist as avenue plantations or in forest areas. For example, in India *Pongamia pinnata* and *Azadirachta indica* trees are commonly grown as avenue plantations on common lands as well as on riverbanks. At present the seeds from these trees are not commercially used to the possible extent. The production needs to be enhanced and this requires favourable strategies where growers are not put to hardship and loss. One of the options in promoting livelihoods of the poor is through the promotion of plantations by user groups or Self-Help-Groups (SHGs) on common pool lands like degraded forests, community owned lands, low quality lands not suitable for annual food crops production, railway setbacks, canal embankments, tank foreshore, etc. The usufruct rights for harvests are ensured to the groups who manage the plantations but the right on land is not extended. Through assured market demand the landless people in groups (SHGs) could handle collection from the decentralized plantations and earn their livelihoods. This strategy along with the strategy to develop/rehabilitate degraded lands through biodiesel plantations could ensure an efficient use of existing natural resources for promoting a win-win solution through biodiesel plantations.[15]

Decentralized Extraction and Centralized Processing

There is a need to promote and utilize the expellers available locally as this will minimize the cost of transport of raw material, and will generate employment in rural areas. This will also ensure an availability of cake in the rural areas and the recycling of cake back to the fields. There is a possibility of using oil directly in the irrigation pumpsets and it can be blended directly with diesel up 10 per cent for use in farm machinery. Electricity generation is also possible in remote areas using filtered oil directly but all these require decentralized extraction. For esterification and biodiesel production a centralized processing facility can be created, which will minimize the cost of transportation and ensure strict quality adherence.

Recycling of Cake for Production of Biogas and Compost

The cake offers an excellent opportunity for reducing the dependence on fertilizers and its marketing will generate additional income. The cake can also be used for production of biogas before composting and both these processes will improve nutrient availability as fertilizer to the crops during the season itself as well as reduce pressure on energy demand for domestic use.

Carbon Trading by Women SHGs

The associated benefit with biodiesel plantations is small income for the rural communities through carbon trading. Under natural conditions *Pongamia pinnata* was observed to sequester 17, 72, 331 and 347 kg carbon per plant at 5, 10, 15, 25 years of age, respectively in a study carried out in Adilabad district.[16] Adilabad district of Andhra Pradesh (AP) State in India is richly endowed with a good forest cover (47 per cent), black soils (Vertisols), and substantial rainfall (1,100mm). The district has a large presence of indigenous people, comprising *Gonds*, *Lambadas*, and others.

Powerguda, a remote tribal hamlet in the Adilabad district, became an environmental pioneer when it sold the equivalent of 147 tons of carbon dioxide in verified emission reduction as carbon replacement to the World Bank in October 2003. The World Bank paid US $ 645 to Powerguda women SHGs to neutralize the emissions from air travel and local transport by international participants attending its international conference in Washington, USA held on 19-21 October 2003. This was the first time that the multilateral agency made a direct payment to an Indian village for exporting environmental services.[17] The emission reduction was calculated on the basis of 51 tons of *Pongamia* oil substituting for petroleum diesel over 10 years from the planting of 4500 *Pongamia* plants in 2002 (see Table 7). The carbon income was ploughed back by the women SHGs for raising a nursery and planting of *Pongamia* trees. The women's group are able to raise 20,000 seedlings of *Pongamia* and *Jatropha* from this income every year and generate further income through sale of seedlings. Most of seedlings are sold to the forest department, but some are also planted on field boundaries, farm bunds and community owned lands. The women are also members of the forest protection committee formed to protect the nearby forest under the government's Community Forest Management project. Other village activities include social networking, watershed management, improved agricultural pratices and income generating activities. The establishment of an oil mill to crush *Pongamia* seeds into oil has helped the women to increase income through the sale of oil and oilcake.

Table 7: Carbon Calculations for Powerguda Village, 2003-2012[1]

Year	Oil yield (kg)	Trees	Total oil yield (kg)	C(t)	CO2 eq (t)	Value (US$)	Discount value (at 3%)	NPV
2003		3,600	410	0.32	1.17	6.72	1.00	6.72
2004			494	0.39	1.41	8.09	0.97	7.85
2005			590	0.46	1.69	9.66	0.94	9.08
2006	0.5		1,125	0.88	3.22	18.43	0.91	16.77
2007	1		3,600	2.81	10.31	58.97	0.88	50.71
2008	1.5		5,400	4.21	15.46	88.45	0.85	51.89
2009	2		7,200	5.62	20.61	117.94	0.82	96.71
2010	2.5		9,000	7.20	26.43	151.24	0.79	119.48
2011	3		10,800	8.42	30.92	176.90	0.76	134.45
2012	3.5		12,600	9.83	36.07	206.39	0.73	150.66
			51,219	40.13	147.29	842.79		644.32

Note: [1]Carbon value is calculated at US$ 21 t^{-1} of carbon, or US5.722t^{-1}$ of CO_2 equivalent
Source: D'Silva *et.al.*, 2004.

The pioneering work of extracting oil from *Pongamia* seeds, exporting environmental services to the World Bank and improved income level has given the people a sense of pride and has put the village on the map of the world. Women's involvement in nursery raising, plantation, carbon trading has triggered the social capital development and social cohesion. Today, the women are able to manage their finances, are sensitized about health and nutritional issues such as HIV, etc. and need education for all. There is no migration from the village and this may be attributed to an increase in the level of income in each family. The improvement has come mainly from agriculture (93 per cent) and forest (7 per cent) which translates to Rs.27,821 (2002-03) from Rs.15,677 (1999-2000). In 2003, the four groups of SHGs in Powerguda had Rs. 5,52,000/- as total savings, which worked out Rs. 6,608/- per household. Now, they are in a position to get loans from banks and are out of the clutches of moneylenders. Powerguda action has inspired several neighboring villages to plant *Pongamia/Jatropha* trees on a large scale and this has been repeated in 20 other villages in Adilabad district.[18]

Returns from Plantations

Not much research work has been undertaken on these plantations and their economic returns. Several types of returns from the growing and the use of products from *Jatropha* and *Pongamia* need to be carefully estimated. There is a need for research on the operational scale to identify plus trees and improved management techniques for higher productivity and economic viability. The economic returns may vary from place to place depending on the climate, soil and management practices. The tangible benefits, include the market prices of different products like diesel and by-products like cake and glycerol while intangible benefits are many. Besides tangible benefits, there are innumerable intangible benefits like:

- Potential to produce a green fuel that will reduce carbon dioxide emissions as biodiesel will be recirculating atmospheric CO_2 through the process of photosynthesis.
- Greening of waste and marginal lands, which has positive impact on hydrology.
- Alleviate soil degradation, desertification and deforestation and conserve soil and rainwater.
- Improved ecosystem and environmental sustainability.

Conclusions

Tree based oilseeds offers scope for rehabilitating degraded lands and improve livelihoods in developing countries. Green cover over barren and unproductive lands will reverse the process of degradation caused mostly by water erosion. The fertility of these marginal lands will improve through recycling of nutrients from the deeper layers, addition of leaf litter, nitrogen fixation (*Pongamia*) and carbon will be sequestered unlike fossil fuels. Studies have shown that *Jatropha* returns 19 kg N ha^{-1} $year^{-1}$ through litter fall from the third year onwards.[19] Employment generation from plantation, harvest and processing activities will reduce migration from the rural areas, which is a big concern in most Asian countries. Participation of women SHGs in managing the plantations will boost their livelihoods and will empower the women. Recycling of cake will reduce the dependence on inorganic fertilizers and will pave the way for organic farming. Further, there is scope of earning carbon credits and the additional benefits can be passed on to the growers.

As necessary market demand, government support and technologies to process do exist, however, the potential cannot be tapped mainly because of insufficient availability of feedstock. Biodiesel plantations for rehabilitating degraded lands, and increasing income from low quality lands provides a win-win situation for protecting the environment, increasing income, and generating employment opportunities in rural areas. However, the lack of scientific information about suitable management practices as well as identification of high-yielding accessions and lack of high yielding cultivars on a large scale holds back development in this area. There is an urgent need to undertake detailed research for development of management practices, high-yielding cultivars, mass multiplication techniques, suitable development models for increasing supply of raw material for biodiesel production. The by-product cake after extraction of oil is a potential source of valuable plant nutrients as well as organic matter for improving the soil quality of tropical soils, and is a good source of energy through biogas for meeting the domestic energy needs. In conclusion, the development of biodiesel plantation provides win-win situation and needs targeted investments towards research and development aspects for ensuring the supply of raw material.

Endnotes

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Liquid Biofuels in South Asia: Resources and Technologies

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Abstract: South Asia with a geographical area of 5.1 million hectares is home to 1.5 billion people and is witnessing a sustained and rapid economic growth. As a result primary energy demand in this part of the globe has increased by 64 per cent since 1991 reaching 584 mtoe (million tons of oil equivalent) in 2003-04. All countries in this region are net importers of petroleum fuels. In this context, as an indigenous and renewable energy source, the use of biofuels can play a vital role in reducing the dependence on petroleum import and catalysing the rural economic development. In the last few years, interest in these green fuels has grown dramatically followed by the equivalent market responses.

This paper deals with the potential of biofuel production in South Asia in terms of availability of resources, existing processes and technologies. Biotechnological interventions to improve the economic competitiveness of biofuels have also been identified and scrutinized. It is concluded that a well-conceived biofuel programme with effectual cooperation among the countries has the potential to lead South Asia to high rates of energy sustainability.

Introduction

Energy Scenario in South Asia

Home to one fifth of the total world population, and having seen a rapid economic expansion in the last decade, South Asia's primary energy consumption witnessed an augmented growth of 64 per cent reaching 584 Million tons of oil equivalent (Mtoe) in 2003 – 04.[1] Against the backdrop of an enhanced oil import and growing apprehensions on sustainability, need for energy security has become a vital component of the economic sustainability of the region. This requires not only that existing fuel resources must be utilized as economically as possible but also that the energy sources used in this fuel system must be diversified.

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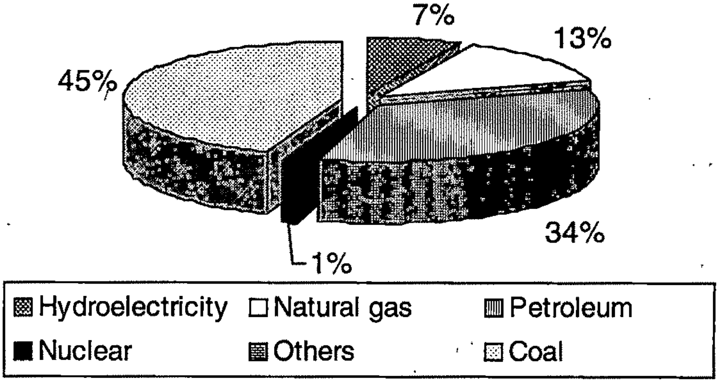
Figure 1: Sources of Energy in South Asia (2002)



Though there are significant variations among the countries in the composition of the energy mix, more than 90 per cent of the South Asian energy demand is from fossil fuels.[2] In this, petroleum accounts for more than 34 per cent (see Figure 1). More than 70 per cent of the oil demand is met through import and the quantum of imported petroleum is projected to be double by 2020. In this context, liquid biofuels as an alternative to petroleum can play a significant role in the energy scene of this region. Recent developments have made these fuels economically interesting in view of the resource potential and the possibility of improving environmental performance, along with employment generation and empowerment of the rural economy. However, development of this biomass-based energy sector would ensure the availability of adequate resources and efficient technologies to keep pace with society's need for these clean and viable alternatives. This paper looks into these aspects covering different resources, state of the art conversion technologies, research needs and technological innovations for timely implementation of a sustainable biofuels programme in South Asia.

Biofuel Options in South Asia

Biofuels can be defined as the renewable liquid fuels, derived from biological raw materials, which can be used as a substitute to petroleum fuels. On the basis of commercialization feasibility, mainly three liquid fuels could be considered in South Asia. These are straight vegetable oil, biodiesel, and bioethanol.

Vegetable oils have been used in the world as a fuel substitute since 1800 to run diesel engines.[3] The type of vegetable oil varies in different regions depending on the availability. As far as South Asian countries are concerned, non-edible oils are considered as a major resource for this purpose as edible oils are in short supply. Non-edible oils are being used in stationary engines in different parts of India. Pongamia oils have been used traditionally for lighting and for the pumping water in southern India. Currently a blend of pongamia oil with petrol is being experimented up on for use in vehicles.[4] Nepal is also going ahead with vegetable oil as a fuel substitute especially for simple blending with kerosene for use in the locally available stove. During the 90s, the Royal Nepal Academy of Science and Technology (RONAST) started exploring the potential of *Jatropha curcas* seeds, which contain 50-55 per cent fixed oil (Boswell, 2001). The Ministry has already planted some 40,000 *Jatropha* plants on marginal lands for Local Development and the Institute of Forestry in Tanuhun district that meet the target of the annual diesel requirements of fifteen agro-processing mills in the district. Research is going on in RECAST (Research Centre for Applied Science and Technology) and the GEM (Green Energy Mission) are doing research and development in this subject. In Sri Lanka, attempts are being made by private sector institutions to cultivate *Jatropha* for biodiesel production. The Ministry of Science and Technology of Sri Lanka is in the process of carrying out yield determination trials for *Jatropha*. Though vegetable oil has high calorific value, one of the major problems associated with its use in engines is its high viscosity. However, straight vegetable oil can be chemically processed to a less viscous form called esters or what is commonly known as biodiesel, which could be conveniently used to substitute diesel.

Biodiesel is relatively new term in the South Asian context. Exhaustive plans are being chalked out in different parts of the region especially in India for a comprehensive non-edible oil based biodiesel programme. India has taken the *Jatropha* plantation scheme to the highest level of national discussions with a large number and variety of institutions already involved in the pilot scale experimentations. With a view to blend diesel with biodiesel, the Government of India has launched the National Mission on Bio-diesel to address socio-economic and environmental concerns. The first phase of the programme intends to replace 5 per cent of diesel consumption by 2006 with 2.6 million tons of Jatropha biodiesel.[5]

Ethanol is produced in the range of a billion litres in South Asia. Much of the production comes from India and Pakistan and finds applications in the industrial and potable sector. Use of alcohol as a fuel became a significant option in these countries very recently. In Bangladesh, at present LPG is making inroads and biofuels are yet to make an impact. Private companies are making plans to manufacture fuel alcohol in the country. An investment of $4.5 million will be made for a 12000litres/day ethanol plant, which uses molasses as a feedstock (*Bangladesh Observer*, 2005). The major step forward in the Indian ethanol programme was the Government of India notification on EBP (Ethanol Blending Programme). This notification made five per cent ethanol doping in petrol mandatory in nine states and four territories, with effect from 1 January 2003.

Resources for Biofuel production

Biodiesel Resources

Land Resources for Energy Plantations

As stated earlier, channelising non-edible oils for biodiesel production may be a more feasible option in South Asia. Possible species such as *Jatropha curcas*, *Pongamia pinnata*, *Calophyllum inophyllum*, *Calotropis gigantia*, *Euphorbia tirucalli* and *Boswellia ovalifololata* are very hardy and are able to grow in adverse climatic conditions. Therefore, plantations of these non-edible oil crops can be targeted on underutilized, fallow barren or degraded or under stocked forests such as in drought prone areas. Over a period of ten years (1991 to 2000) although Asia recorded the largest growth (2.5 per cent) in the share of agricultural land to total area, minimal growth was noted in South Asia (see Table 1).

Table 1: Land Resources in South Asian Region

Country	Total land area (sq km)	Share of agriculture lands	Share of forest land
Bangladesh	146, 991	60.2	5.9
Bhutan	40,372	17.4	59.8
India	3.05 Million	60.0	17.4
Sri Lanka	65,610	32.5	29.6
Maldives	200, 000	—	—
Nepal	274,620	25.3	36.7
Sri Lanka	65,610	32.5	29.6
Pakistan	770,880	22.2	2.4

Source: The Role of Wood Energy in Asia, FAO Corporate Document Repository, 2004.

The total degraded land in Nepal is around 5 million hectares (33 per cent of the total area of the country) with the largest area in middle mountains.[6] This area comprises non-cultivated inclusions, grasslands, shrub lands and degraded forests. The forests and forestlands cover 33 per cent of the total land area. With 75 per cent of the total cultivated area of 20.68 million hectares irrigated, Pakistan is among the countries with the most irrigated land in the world. Only 4 per cent of the country is classified as forestlands. The marginal and wastelands in Pakistan comes around 57 million hectares.[7] As per the recent waste land atlas of India,[8] about 63.85 million hectares are can be classified as wastelands. However, it may not be reasonable to assume that the entire classified wastelands are available for energy plantations.

Forest Resources for Biodiesel Production - Tree Born Oil Seeds

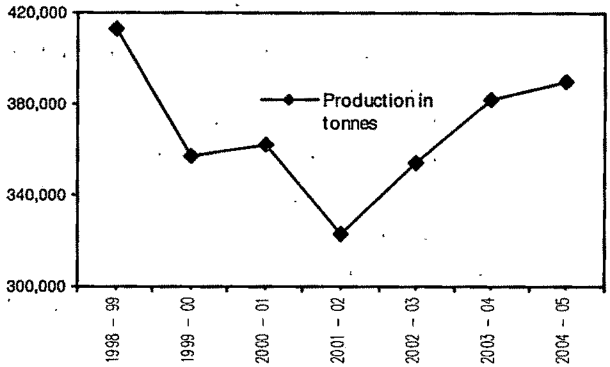
South Asia is home to abundant forests, bearing a variety of tree born oil seeds, which could be explored for biodiesel production. Nepal forests are reported to have vast quantities of non-edible oil seeds with over 100 plant species containing more than 30 per cent fixed oil. The annual potential fatty oil yield from seeds of *Pinus roxburghii* is estimated at 3 million tons in Nepal but it has not been commercially exploited until now. Apart from being a major source of building timber, Sal (*Shorea robusta*) is a prolific producer of seeds and has a high oil content. The actual authorized and unauthorized collection of Sal seeds in Nepal is only about 41,000 tons per year.[9] The pine oil (turpentine) is another source of bioenergy.

Bhutan has many trees and shrubs, which are potential sources of oil in both sub-tropical and sub temperate zones of the country. A few common species traditionally used by villagers in different parts of the country are *Gynocardia odorata, Aesandra butyracea, Symplocos paniculata,* and *Shorea robusta.*[10] But no systematic study has yet been carried out to survey Bhutan's potential for producing vegetable oil. In Pakistan, 20 thousand tons of walnuts are reported to be produced in forests.[11] Additional oil yielding crops of Pakistan are cotton and various cultivated varieties of crucifers like rape and mustard seeds. In the Maldives and Sri Lanka, coconut is a widely grown agricultural product with a production of 19,00,000 metric tons and 35,000 metric tons respectively.[12]

Methanol for Biodiesel Production

Alcohol is an essential reagent for the production of biodiesel. Generally, alcohol requirement is a minimum of 10 per cent by weight of biodiesel.

Figure 2: Yearwise Methanol Production Scenario in India since 1999



Source: India Infoline Sector Database, 2005.

The methanol based biodiesel sector is not fully reliable because of its import dependency and related price fluctuations. Further more it is significant to note that any fluctuation in the price of alcohol reagent can disturb the stability of the biodiesel price drastically. As a major methanol producing country in the South Asian region, the scenario in India is very critical and is represented in Figure 2.

It is clear from the table that the Indian methanol production capacity is half of the domestic requirement, which comes around 6,20,000 metric tons. In fact, the availability of raw material (natural gas) in India is very limited and it has multiple uses for which the government defines the priority. Also despite an exponential rise in demand, new methanol capacity is not being put up. Therefore if methanol is used for biodiesel production, the present resources will not be sufficient to meet the demand. In this context, ethanol can be foreseen as a sustainable chemical, and strategies need to be drawn out to enhance its production from alternate resources.

Resource for Ethanol

Different resources that can be utilized for ethanol production and their comparative production potential are given below in Table 2.

Sugarcane Molasses and Sugarcane Juice

Sugarcane is grown in both tropical and subtropical regions in South Asia. In 2003, India produced over 289 million tons of sugarcane, Pakistan 52 million tons and Bangladesh 6 million tons.[13] A majority

Table 2: Different Substrates for Ethanol Production and their Comparative Production Potential

Crop	Ethanol production potential (L/ton)
Sugar cane	70
Sugar beet	110
Sweet potato	125
Potato	110
Cassava	180
Maize	360
Rice	430
Barley	250
Wheat	340
Sweet sorghum	60
Bagasse and other cellulose biomass	280

Source: Nigam and Agarwal, 2004.

of molasses to ethanol plants are located in tropical and sub-tropical regions. In India, ethanol production is constrained because of its dependence on a single source. The maximum potential of ethanol production from molasses is estimated to be about 2.5 billion litres only. Enhancement in production to meet the huge demand at a reasonable price would only be possible by exploring alternate resources.

Utilization of cane juice directly for ethanol production is one of the major options to enhance ethanol production. In the context of the rising interest on fuel ethanol, it gives an opportunity to the sugar industry to diversify its factories as sugar ethanol and co product complexes. In a sugar factory attached with a distillery, if the sugar price is low, more sugars can be diverted to ethanol production in the form of cane juice or cane syrup. In the off-season, molasses can be used for ethanol production. Alternatively, primary juice can be used for sugar production and secondary juice can be utilized for ethanol production. It has also been projected that such a proposition might lead to additional benefits like stable sugar prices, export quality sugar production, adequate availability of ethanol, higher potential for export power and remunerative prices for sugar cane. In this context, the national sugar policy in India can be amended for facilitating the use of sugarcane juice for ethanol production.

Starch based Feedstocks and Fruits

Many wild fruits can be used as a good feedstock for ethanol production. For example, the fruit of the wild persimmon tree (*Diaspyrus lotus*) is rich in sugars and is found abundantly in Pakistan forests. An average tree yields 120 kg of dry fruit and a significant portion is not collected. Other commonly found wild fruits are gurgura (*Reptonic buxifolia*), deela (*Apparis aphlla*), Pelu (*Salvodara oleides*), jujube (*zizyphus spp.*), and Sumal. In 1998, 21.8 thousand tons of wild fruit production is reported in Pakistan. Being the fifth largest date producing country in the world, Pakistan is also experimenting with the option of bioconversion of date sugar to ethanol.[14] Cashew fruits (*Anacardium occidentale* L), available in the southern states of India, are other potential substrates for ethanol production. In Goa, these are trampled by foot to extract the juice for the locally famous distilled liquor, *feni*. Surplus cereals and starchy crops can also be used for ethanol production. For example, in Bangladesh 40 lakh tons of potato were harvested in 2005 while the annual demand is around 30 to 35 lakh tons[15] (FAO, 2004). On the other hand, Pakistan's rice production is likely to increase to 5.4 mt enabling it to achieve a $1 billion export target. Possible ways need to be looked into for apportioning these surplus starchy materials economically for ethanol production.

Sweet Sorghum

Sweet sorghum (*Sorghum Bicolor L)* is one of the most drought resistant agricultural crops as it has the capability to remain dormant during the driest periods.[16] Of the many crops being investigated for energy and industry, sweet sorghum is one of the most promising candidates, particularly for ethanol production principally in developing countries like India. It is the third major cereal in India. The possibility of year round cultivation and tolerance to acidity, alkalinity and salinity are other advantages. It requires less water and fertilizer compared to sugarcane. As molasses production is limited to around 4-7 months, based on the sugar cane crushing season, sweet sorghum can be cultivated and processed for ethanol during the non-crushing season. The crop can provide a cane yield of 30-40 tons/ha and 50-60 per cent juice recovery is possible under factory conditions.[17] Through a detailed analysis of the ethanol demand-supply scenario and resources assessment, suitable planting dates of sweet sorghum can be worked out. But this should be done very carefully so as to adjust with the sugarcane sector.

Sugar Beet

Two thirds of world sugar production is from sugar cane and one third from sugar beet. These crops are complementary as they are cultivated

Table 3. Comparison of Cane and Sugar Beet

Properties	Cane	Sugar beet
Cycle of crop	10 – 11 months	5 – 6 months
Yield per acre	25 – 30 tons	35 – 40 tons
Sugar content on weight	12 – 16 per cent	14 – 18 percent
Sugar yield	3.0 – 4.8 tons /acre year	4.9 - 7.2 tons/ acre year
Ethanol yield	1700 – 2700 litre/ acre /year	2800 – 4100 litre /acre / year

Source: Winrock International, 2004.

for specific requirements in two different climatic belts. In European countries, sugar beet is preferred. The advantages with sugar beet are a lower cycle of crop production, higher yield, and high tolerance of a wide range of climatic variations, low water and fertilizer requirement (see Table 3). Compared to sugar cane, sugar beet requires 35-40 per cent less water and fertilizer.[18]

Cellulosic Resources

Lignocellulosic biomass, for example agro-residues, appear to be one of the most attractive and low-cost future feedstock options for fuel ethanol production. As shown in Table 2, agro-residues have a higher theoretical ethanol yield compared to sugarcane. Further, agro-residues available in large quantities are cheaper compared to sugar crops, and do not require additional land resources for their cultivation. In India, the current production of agro-residues is about 800 million tons. Even if 10 per cent of the agro-residues are utilized for ethanol production, around 15 million kilolitres of ethanol can be produced.[19] Rice straw, wheat straw, sugarcane bagasse, and sugarcane tops are the main residues (see Table 4).

Table 4: Potential of Different Agro-residues for the Production of Ethanol

Agro-residue	Cellulose (% wt/wt)	Hemicellulose (% wt/wt)	Lignin (% wt/wt)	Theoretical ethanol yield (litres/ton)
Rice straw	41.36	20.36	12.06	346.00
Wheat straw	39.63	24.07	16.97	359 .00
Ground nut straw	36.55	13.94	31.28	319.96
Rice husk	44.06	17.85	17.20	392.33
Sugarcane bagasse	33.60	29.00	18.50	351.00

Source: Iyer, Rao, and Grover (2002); DoE (2005).

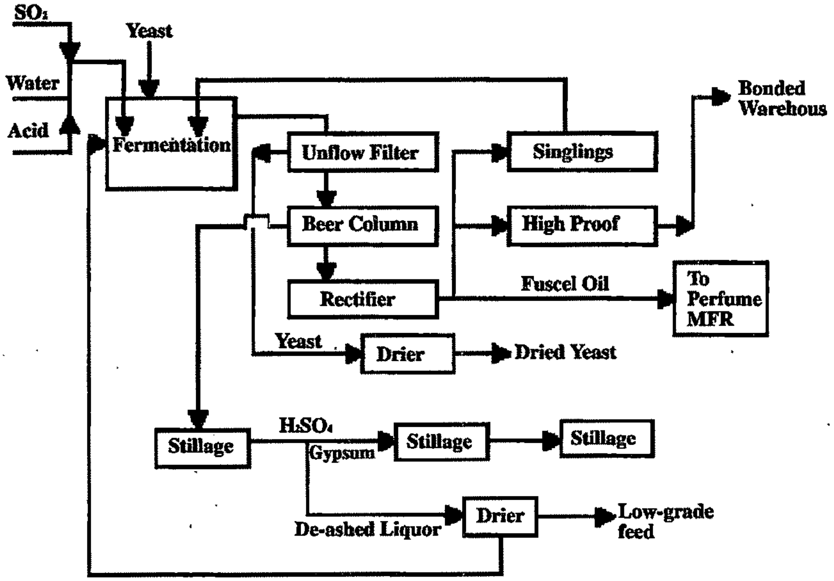
Processes and Technologies for the Production of Biofuels

Ethanol: State of Art

Conversion of Molasses to Ethanol

During the commercial fermentation process, molasses containing approximately 43 per cent fermentable sugars are diluted and fermented. Mash is diluted to the aqueous solution of sugar whose characteristics and composition are favourable for the fermenting organism in the efficient production of ethanol. Actively growing yeast ferments the sugar present in the solution to ethanol. Once the fermentation is complete, after settling of the suspended solids, the supernatant of the fermented mash is drawn off and pumped to the distillation house where ethanol is distilled out followed by dehydration for the production of anhydrous alcohol (see Figure 3). This is accomplished in two columns: the distillation and rectification columns, coupled with molecular sieves in which a mixture of nearly azeotropic water and ethanol are purified into pure ethanol. The stripping column

Figure 3: Different Process Stages for the Conversion of Molasses to Ethanol



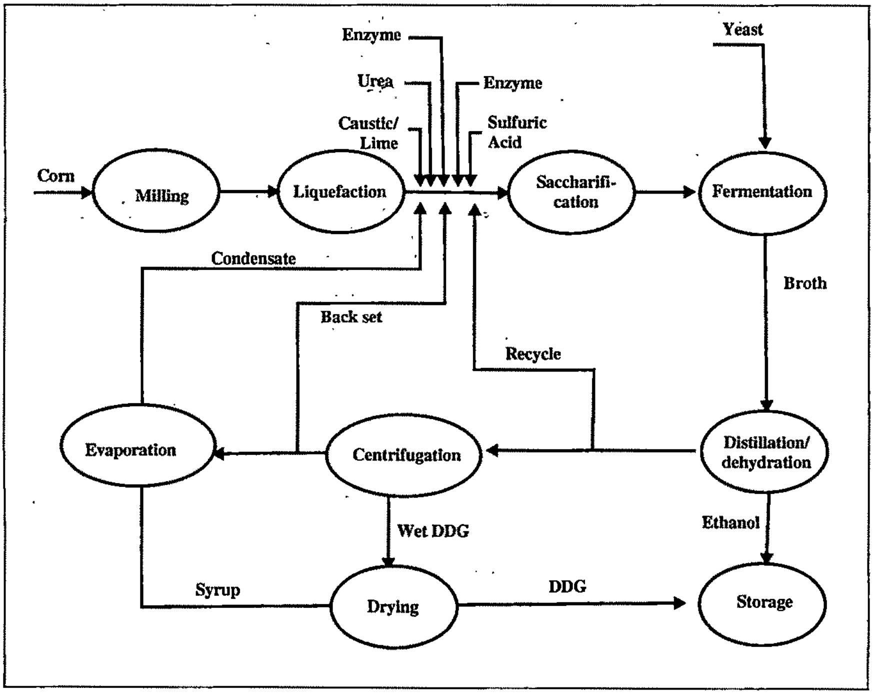
bottom liquid rich in BOD and COD is treated in biomethanation plant containing 5 per cent solids is concentrated to 40 per cent in evaporators. The concentrated mother liquor is dried as powder in a spray dryer. The CO_2 produced is collected and bottled.[20]

Conversion of Starch to Ethanol

Starch based feedstock need pre-treatment and hydrolysis of starch constituents for the preparation of starch molasses, which can then be fermented to ethanol. The first step of hydrolysis process consists of milling the grains to release starch from the raw materials. The step can be dry or wet.

In the dry milling process, the process is divided into three major stages: liquefaction, saccharification and fermentation. During liquefaction, the mash is mixed with hot water and μ amylase enzymes and consequently starch polymers are broken down to maltose and higher oligomers (see Figure 4). Continuous saccharification usually takes place in a CSTR where the enzymatic hydrolysis leads to the

Figure 4: Different Process Stages for the Conversion of Starch to Ethanol



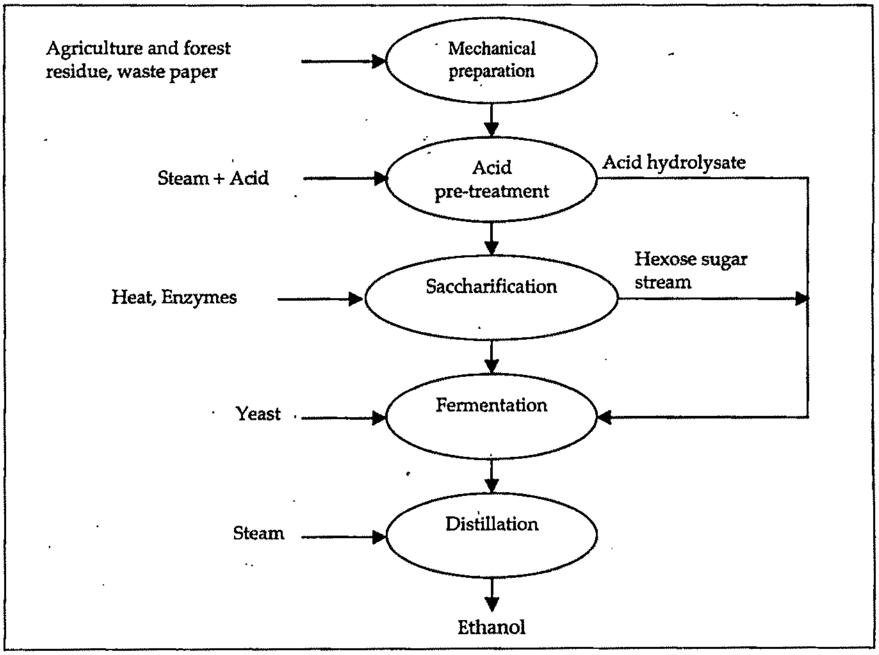
production of glucose sugars. The saccharified mash is then cooled to 32 °C and fed to the fermentors for production of ethanol.[21]

The wet milling process is used to obtain as many usable by-products as possible from different components of feedstocks. For example, in the case of corn it is first steeped in water to separate the kernel. Following this, the corn is ground and washed to further separate the kernel. When the corn is processed, the germ is removed to form corn oil and the starch is used for ethanol production.[22] The remaining solids, gluten meal and gluten feeds are sold as high protein livestock feed.

Cellulose-based Ethanol Production

For the conversion of cellulosic material to ethanol, two key steps are required. At first, cellulose and hemicellulose have to be hydrolyzed to simple monomers while in the second stage, the conversion of monomer sugars to ethanol is done. A large number of thermal, chemical and biological processes are under investigation for the saccharification of cellulose and hemicellulose. Till date, research primarily has focused on chemical pre-treatments such as dilute acids, alkaline, organic solvent

Figure 5: Different Process Stages for Biomass Conversion to Ethanol



treatment, ammonia, SO_2, CO_2, etc.[23] and also on enzymatic hydrolysis. The topic is subjected to intensive R&D in many developed countries though research on this subject is in its infant stage in South Asia. But it is important to note that South Asia has abundant ligno-cellulosic resource compared to any other region in this globe.

Internationally, there is an increased interest in commercialization of cellulose to ethanol technology. Research efforts have improved yield and reduced the time to complete the process. The National Renewable Energy Laboratory (NREL), USA, has modelled many potential process designs and estimated the economics of each process. The Department of Energy, USA, has chosen a target-selling price of 1.07 dollars per gallon by 2010. Presently, the technologies in competition include concentrated acid hydrolysis by Arkenol Inc., pentose and hexose fermentation process by BC International Corporation, and enzymatic hydrolysis process by logen.[24] The feedstocks include rice straw, sugarcane bagasse, wheat straw, and wood wastes.

Straight Vegetable Oil – Extraction from the Seeds

The extraction of oil from the seeds is generally mechanical for small-scale processes or it involves the use of solvent such as hexane or it can be the combination of both the processes. Depending upon the type of seeds, various types of grinding, cracking, flaking and rolling equipment is used to rupture oil cells to allow egress of the oil. Steaming is provided in order to increase the process efficiency. Softer oil seeds and nuts can be processed manually by means of ghanis. Further extraction of residual oil from the seed cake with the solvent can increase the oil recovery to a significant extent. There are several oil presses developed for extraction of oil from non-edible oil seeds especially for smaller scale extractions. Appro Tec's Mafuti Mali press, The Sundhara Press, Yenga hand press, the Komet Press, Caltech expellers and Bielenberg Ram Press are a few examples.[25]

In solvent extraction, oil is extracted using an organic solvent generally hexane. Residual cake is washed with solvent, under a counter current flow, producing an oil/solvent mixture (termed a miscella) and a residual meal containing solvent. The miscella is subjected to evaporation and steam stripping to recover hexane from the oil. The hexane is then separated from the water mixture by physical settlement and is recovered for re-use in the extraction operation. The solvent-laden meal is processed by steam distillation in a de-solventizer to recover most of the hexane content. The meal can find applications as animal feed, fertilizer and also for biogas production.

After the extraction oil, the next step is the refining process, which generally includes degumming, neutralization, bleaching, deodorization and further refining to get the final product.

Biodiesel Production

In simple terms, for the transesterification to take place, alcohol, catalyst and oil are made to react in a reactor and agitated for approximately one hour for 60°C. The reaction is sometimes done in a two-stage system. In the two stage system, 80 per cent of the alcohol and catalyst are agitated in the first phase. The reacted stream then undergoes a glycerol removal step before entering into a second reactor in which the remaining alcohol and catalyst are added.[26] The system has the potential of using a lesser amount of alcohol when compared to the single stage systems.

Both batch and continuous transesterification processes are being used commercially. While batch processes are used for small-scale systems, continuous processes are widely used for large-scale biodiesel manufacturing. In continuous processes, generally CSTRs (Continuous Stirred Tank Reactors) in series are used. In a plug flow reactor system, which behaves as it were a series of small CSTRs chained together, the reaction mixture moves in a continuous plug with little mixing in the axial direction. The result is a continuous system that requires rather very short residence times as low as 6 to 10 minutes for the completion of the reaction.[27] Following the completion of transesterification reaction, the glycerol is removed from the esters. Due to the very low solubility, separation between esters and glycerol occurs rather easily and can be accomplished with either settling tank or a centrifuge.

The maximum amount of free fatty acids acceptable in a base catalysed system is generally less than 2 per cent. Feedstocks having free fatty acids higher than this needs special treatments to eliminate the problems due to soap formation. The processes generally adopted to process the free fatty acids are given in the following sections.

Caustic Stripping: Caustic stripping is also referred to as catalytic refining. In this process, the free fatty acid content of the feedstocks is made to react with caustic soda and the resulting soaps are stripped out using a centrifuge. The refined oils are dried and sent to the transesterification unit for further processing. Instead of disposing off the soap mixture, it can be acidulated and esterified using acid catalysis in a separate reactor

Glycerolysis: Glycerolysis is done in a counter current reactor where sulphuric and/sulfonic acids and steam hydrolyse tri glycerides into free fatty acids and glycerol. After the separation of glycerol, pure free fatty acids are acid esterified in another reactor to transform them into esters. The esters are then neutralized and dried. Yield can exceed 99 per cent and the processes can uptake very high FFA and low cost feedstocks.[28]

Non-catalyzed Esterification Processes

Co-solvent process: One of the major problems associated with trans-esterification of tri-glyceride is the extremely low solubility of methanol in tri-glyceride. Utilization of a co-solvent, which facilitates the solubility of methanol can reduce the reaction time and the reaction temperature. Tetra hydro furan is used as the solvent, which has a boiling point close to that of methanol. The system operates at 30°C and reaction takes 5-10 minutes for its completion. In this process, the ester-glycerol phase separation is clean and the final products are catalyst and water free. But the equipment volume has to be larger because of the additional volume of co-solvent. At the end of the reaction, methanol and co-solvent are recovered in a single step.

Super Critical Process: In the processes based on super critical fluids also, the problems related to the phase separation are not encountered and a single phase is found due to increase in the dielectric constant of methanol in the super critical state. As a result the reaction was found to be completed in a very short time within 2-4 minutes when the oil to alcohol ratio is around 1:42 at pressures greater than 80 atm and at temperatures ranging from 350 to 400°C.[29]

Research Priorities – Role of Biotechnology

Biotechnology plays a vital role in encouraging the use of cleaner and environmentally friendly fuels. Regarding ethanol, biotechnology tools can help in developing genetically engineered enzymes and microorganisms for the efficient fermentation process. Development of an organism that can ferment all sugars found in biomass is a critical factor behind the success of the biomass to ethanol programme. The organism should have the properties of both desired substrate utilization and product formation. This can be accomplished by the production of a fermentation system, which allows a fast rate with high product selectivity and concentrations.

Another main challenge today is to increase the effectiveness of the enzyme converting the cellulose. Increasing the specific activity of the enzymes in the cellulase complex can reduce the cost of cellulases that act on pre-treated biomass used for bioethanol production.

For the production of biodiesel, enzyme catalysed transesterification reactions were found to be much more environment and user friendly. But this technology requires further R&D to increase the effectiveness of the enzymes for an efficient reaction so that the process becomes economical. Plant biotechnology can help in strain improvement; in the case of ethanol, it can produce crops with high sugar/starch content. With respect to biodiesel, varieties having higher seed yield with high oil content is preferred. Prospects do exist in identifying germplasms for developing improved varieties with better yield, better oil quantity and quality, early flowering, etc. using a variety of approaches like mutation breeding, tissue culture, and transgenics.

Conclusions

South Asian countries have enormous potential for liquid biofuels in terms of their diverse feedstocks with suitable edapho-climatic conditions besides having a complementary endowment on a contiguous land mass. However, there is a need for organised planning and systematic research mission to harness this potential for a sustainable biofuel programme.

As land requirement emerges as a major pre-requisite for the development of biodiesel sector, there should be proper identification programmes for wastelands and marginally productive lands. Moreover, plantation of oil-bearing species could be strictly targeted in these lands, with out compromising on food production.

Further more, respective governments may undertake identification of existing resources and site-specific feedstocks. National Mission on Biodiesel being launched by government of India is a major initiative in this direction. Choice of appropriate species also plays a significant role in such programmes. Selection of the species and provenance must aim at identification of the ones, which suit to the specific locations enhancing the economic viability of production and biological productivity of the land.

Technological challenges do exist in channelising many inexpensive alternate feedstocks for biofuel production. Typical example is cellulose based ethanol production. Therefore it is necessary to have extensive research efforts and technology development in these lines. Import of full-fledged technology from other countries is possible especially in biodiesel. But this could be coupled with indigenous technological interventions so as to fit those technologies in the regional context.

There is a definite need for policy and legislative framework for biofuels. The declaration of the agreement on South Asian Free Trade Area (SAFTA) gives hope and aspiration for added efficient cooperation in the promotion of biofuels too. It can help in promoting fair trade practices in biofuels based on efficient market mechanisms with the elimination of market distortion practices of implicit and explicit subsidies. In short, a well conceived biofuel programme with effectual cooperation among the countries has the potential to lead South Asia to high rates of energy sustainability.

Endnotes

[1] Sankar, 2005.

[2] Hussain Leelaratne and Razaak 2002.

[3] Kovarik 1998; Greg 2004; Peterson, Wagner, Auid 1983; Peterson and Auid 1991; Peterson 1986.

[4] TERI, ISEC and ICRISAT, 2005.

[5] Planning Commission, 2003.

[6] FAO, 1989.

[7] FAO, 1989.

[8] NRSA, 2000.

[9] FAO, 1995.

[10] Chhetri, 2000.

[11] FAO, 1995.

[12] FAO, 2004.

[13] Godbole, 2002.

[14] Noor, Hameed Bhatti and Tunio, 2003.

[15] FAO, 2004.

[16] Gnansounou, Duriat and Wyman, 2005.

[17] Ratnavathi, 2004.

[18] Gokhale, 2004.

[19] Assumptions: (a) agro-residues contain, on an average, 50 per cent cellulose and hemicellulose sugars; (b) conversion efficiency is 60 per cent; and (c) average theoretical ethanol yield has been taken as 317 ml/kg (millilitres/kilogram) of dry residue.

[20] Earl and Brown 1979.

[21] Wallace, Ibsen, McAloon, *et.al.* 2005.

[22] NREL, 2000.

[23] Hamelinck, Hooijdonk, and Faaij, 2005.

[24] Schell, Riley, Dowe, *et al.* 2004.

[25] ITDG, 1991.

[26] Van Gerpan. 2005.

[27] Van Gerpan, Shanks, Pruszko, Clements, Knothe, 2004.

[28] Van Gerpan, Shanks, Pruszko, Clements, Knothe, 2004.

[29] Van Gerpan, Shanks, Pruszko, Clements, Knothe, 2004.

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Biofuel Laws in Asia: Instruments for Energy Access, Security, Environmental Protection and Rural Empowerment

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Abstract: Asian countries, due to their rapid economic expansion and population growth, would primarily drive the future global energy demand. Energy security and access concerns would accelerate the shift to renewables, especially biofuels, which also hold the key to environment protection and poverty reduction. Presently, insufficient policy guidelines and legal mechanisms hamper the adoption of biofuels as a viable alternative. This paper evaluates the laws relating to biofuels promotion and use in Asia.

Introduction

Biofuels have started receiving increased worldwide attention of late. Their significance has been duly acknowledged by countries like Brazil, the United States and Europe and now the trend continues in to the Asian economies. The increased economic activity and the large population in this region have resulted in an unprecedented increase of primary energy demand specifically for industrial and transportation uses. Biofuels can ease the supply security of high energy consuming Asian economies and this alternative also be looked upon as an environmentally safe, which could contribute to green house gas reduction. The success of Brazil[1] and its further continued initiatives[2] in the biofuels programme have in fact contributed to this increased awareness that biofuels could save millions in foreign exchange, empower and energize the rural community, and ultimately contribute to overall energy security.

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All the leading Asian economies are net energy importers, making the issue of energy security extremely crucial in the coming years. These countries can take heart from the Brazilian experiments on biofuels using sugar cane. However, replicating Brazil's success may be difficult as many Asian countries face erratic climatic conditions including frequent droughts. Thailand is tapping the potential of tapioca, cassava and palm oil, whereas in Indonesia both palm oil and Jatropha are being tapped. In India, the thrust is on *Jatropha Curcas*, which can be grown in both arid and semi arid regions, while other varieties like *Pongaimia Pinnata*, and *karanja* are also actively promoted.

Biofuels which have been in the news since the oil crisis of the 1970s gained real credibility as petroleum motor fuels when supported by Brazil's Proalcohol Programme.[3] This initiative which also received support from the United States[4] and the European Union,[5] is not about replacing the conventional fuels but supplementing gasoline or diesel fuel through the incorporation of blends. Use of these blends, unlike other alternative motor fuels (LPG, CNG) does not require any vehicle modification. It is interesting to note that Brazil's use of natural fuel comprises 23 per cent of all energy spent in the country, compared to a world natural fuel use of about 1.7 per cent.[6] The success of these programmes was mostly driven by the fact that there were strong legal mandates to accomplish the goals.

High oil prices and volatility in oil supply have resulted in an increased awareness in major energy consuming Asian countries to look for an alternative that is indigenous as well as sustainable. Many nations both in Asia[7] and Europe have renewed their interest in the nuclear energy option and have taken steps to increase hydel power production which has social and environmental costs. The biofuel programme though started late in Asia, has the capacity to catapult this region into a major player, both in terms of ensuring energy security and even prospective exports. Already there are major players from the EU[8] and the US looking at the vast lands of Asia and Africa as a gold mine of potential opportunity. In turn most of the Asian countries are in the process of putting policies and legal mandates in place to have a viable and mandatory fuel mix with bioenergy. This paper explores the existing legal and administrative measures that are facilitating the biofuel programme in select Asian countries based on the availability of documents and information. The study would review the existing and prospective legal measures that are being explored by the governments of India, Philippines, Malaysia, Thailand, Japan and China. The paper concludes with observations by the authors.

Legal Approaches for an Effective Biofuel Programme in Asia: Country Studies

India

India's GDP is projected to be the third largest in the world by 2030.[9] The current rate of population growth would make India the most populous country by 2030, overtaking China.[10] There will be economic demands that will have to be met by an energy mix which is sustainable. Any shortcomings in the supply of energy resources could create major imbalances in the urban-rural economies and will lead to a disruption of growth and income levels. India is not endowed with large primary energy reserves proportionate with her large geographical area. It is projected that the total primary commercial energy supply in India will grow at an average rate of 3.2 per cent over the period 2002-2025/2030,[11] while at the same time there will be a tripling of the energy requirement to reach 709 mtoe from the current level of 325 mtoe.[12] The country is already heavily dependent on the imported conventional energy accounting for 70 per cent of the present levels, and this will increase dramatically in the next 5 decades when India will become the third largest energy consuming country.[13] The world supply has already become critical with volatility and supply concerns; India needs to find alternatives that are indigenous and sustainable. The solution may lie with biofuels that could be sourced from the vast wastelands[14] of the country.[15]

The biofuels programme if pursued in a coherent and earnest way will have multiple benefits, namely, farmers will be directly connected with their livelihood through plantation, society will benefit through a larger goal of employment generation and the consequent rise in income, the governments meet with the expectation of reduced import of conventional fuels thus saving foreign exchange, the rural economy benefits through decentralized rural energization, empowerment apart from employment, apart from large scale environmental benefits such as reduced vehicular pollution and environmental degradation.[16] To make such a large and massive biofuels programme implementable, it is necessary for the governments both at the national and at the local levels to adopt strong policy measures and legally supported mechanisms.[17] The legal measures undertaken and recommended by the government to make biofuels programme viable, productive and sustainable are examined below.

Legal and Policy Position on the Existing Biofuel Programmes

(a) Ethanol Programme

In India, Indian Power Alcohol Act, 1948[18] as early as in 1948, mandated the blending of power alcohol with petrol.[19] The legislation was passed taking into account future energy security concerns and with the object of harnessing India's surplus of molasses.[20] The Act also had provisions for the determination of the procurement price of power alcohol for the purpose of blending it with petrol.[21] However, this mandate was never followed or implemented, perhaps due to the subsequent relative stability in world oil supply and decrease in the supply of ethanol. This Act was repealed in 2000, following an administrative reforms drive to repeal legislations that had not been used. This move could not have been more ill-timed as within two years, the Government of India started the initiative to blend ethanol with petrol, the very object of the repealed Act.

The Government of India Notification on the Ethanol Blending Programme (EBP) dated September 2002[22] gave a big boost to the agriculture sector and to a reduction of environmental pollution. The Notification made 5 per cent ethanol blending mandatory in petrol, in 9 states and 3 Union Territories.[23] Based on the success of pilot projects undertaken in 2001, the ethanol blended petrol (EBP) Programme came into effect from 1 January 2003. In 2004 the Government of India, through an order, initiated measures to withdraw the mandatory order regarding mixing of 5 per cent of ethanol in petrol and a subsidy of 30 paise per litre. Though this has created some sort of confusion, the Government clarified in parliament that the EBP programme continues to be mandatory; in terms of Gazette notification No. 705 (E) dated 27.10.2004 and explains,

> "... the new notification dated 27th October, 2004 is that as long as the prices of ethanol are competitive and reasonable, and the supply of ethanol is adequate, the oil marketing companies will continue to be statutorily required to lift the ethanol and supply ethanol blended petrol in the notified area."[24]

The explanation[25] with regard to the withdrawal of the subsidy of 30 paise is that, when this programme was introduced, the delivery cost of ethanol-blended petrol was higher than the delivery cost of petrol. The oil marketing companies were required to lift ethanol through public tenders, blend the ethanol with petrol at blending depots located across the States and then supply this to retail outlets. Therefore, the government decided to grant fiscal incentives by way of reduction in additional excise duty on petrol meant for blending with ethanol. Accordingly, the additional excise duty of Rs. 6 per litre leviable on petrol was reduced by the Government of India by 30 paise per litre in the case of petrol intended for use in ethanol blended petrol. This exemption was valid only up to 30 June 2004. The five per cent ethanol blended petrol was also exempted from the payment of additional excise duty. This arrangement continued with the exemption of additional excise duty, which was not extended beyond 30 June 2004. In parliament the government informed[26] that there is inadequate supply of ethanol to meet the demands of blending.

> "The ethanol requirement in 2003-2004 was about 363 million litres per annum. But only 196 million litres was made available for purchase by oil refining companies. During 2003 and 2004, difficulties about the sourcing of ethanol have been reported from Maharashtra, Goa, Gujarat, Andhra Pradesh and Karnataka. The regular supply of ethanol has been affected due to the non-availability of molasses resulting from lower production of sugar owing to low sugarcane crop and drought conditions."[27]

Therefore, on the expiry of the contract for ethanol procurement, fresh public tenders were invited by oil marketing companies during the year 2004-05. Despite these tenders, owing to the acute difficulties faced in sourcing ethanol in the Western and Southern regions, the oil marketing companies requested the government to suspend the programme for eight months with effect from 1 August, 2004 and to take a fresh decision during the coming sugar season October 2004-September 2005. This was not accepted by the Government and the Ministry of Petroleum and Natural Gas (MoPNG) decided to continue the programme as one of the main objectives of the programme is to support the rural economy.[28]

But faced with the fact that there was not enough ethanol available to be able to implement a five per cent EBP, the government modified[29] the provisions in the original Gazette Notification.[30] In consideration of the issues related to availability of ethanol at reasonable prices, the government vide notification No. GSR 705(E) dated 27 October 2004 notified that 5 per cent EBP as per Bureau of Indian Standards specifications shall be sold. This sale shall be applicable if the price of sourcing indigenous ethanol for supply of EBP is comparable to the price of indigenous ethanol for alternative uses and if the delivery price of ethanol at the location is comparable to the import parity price of petrol at that location. Along with this if the indigenous ethanol industry is able to maintain the availability of the same for EBP programme at such prices in the notified States and Union Territories.[31]

(b) Biodiesel Programme

The biodiesel programme in India is in the formative years of development. The government is keen to push the biodiesel programme considering the benefits of large scale rural employment and sustainable energy sources that could meet the heavy demands of otherwise expensive conventional fuels. At the national level the biodiesel programme started in 2003 when the Committee on Development of Bio-fuel (Planning Commission) recommended the launching of a National Mission on Biodiesel.[32] The Special focus of the National Mission is on the plantation of *Jatropha* on waste lands. In August 2003, the Ministry of Rural Development (MoRD) was identified as the nodal ministry and in January 2005 a Detailed Project Report was prepared with extensive consultations for the pilot phase (*Jatropha* plantations on 400,000 ha) to MoRD. An unexpected policy statement came on 9 October 2005, when the MoPNG announced the Biodiesel Purchase Policy.[33] Meanwhile, the Government of India's decision to implement the National Mission on Biodiesel is still awaited. At the state government level, several states have initiated biodiesel programmes and polices.

States like Chattisgarh, Uttaranchal, Rajasthan, Andhra Pradesh and Tamil Nadu have already formed nodal agencies for biodiesel development and announced draft biodiesel policies. These states have initiated plantation programmes. For instance, the Uttaranchal Bio-fuel Board (UBB) has planted *Jatropha* in 10,000 hectares in 2005;[34] in Chattisgarh 80 million saplings of *Jatropha* have been planted;[35] while Andhra Pradesh plans to plant *Jatropha* on 16,000 ha and 33 million *Pongamia* saplings in the State[36] and Karnataka has planted 20 million *Pongamia* saplings.[37] Chattisgarh has been the pioneer in this regard. In January 2005, the Chattisgarh Biofuel Development Authority (CBDA) was created to coordinate the state's ambitious plans to reclaim wasteland and create rural employment through *Jatropha* cultivation. The Government, apart from giving tax benefits to industries, is considering the amendment and repeal of laws relating to land use, the setting up agriculture produce marketing committees and has promised the promoters cheap land, subsidized water and electricity to set up plants. On September 2005, the state government notified the "Lease (Government Land for *Jatropha/Karanj* Plantation and biodiesel based processing unit) Rules, 2005". These rules allow a company to lease government 'wasteland' for the payment of Rs 100/ha, which will increase to Rs 1000/ha in the eighth year. Here the state government is using a contract farming and joint forest management approach on waste fallow and agriculture land. In the State of Uttaranchal, Uttaranchal Bio-fuel Board (UBB) has been constituted as a nodal agency for biodiesel promotion in the state. During August 2004, Uttaranchal Biofuel Mission was launched.[38] The UBB, so far has undertaken *Jatropha* plantation in an area of 100 thousand hectares and has established a *Jatropha* Gene Bank to preserve high yielding seed varieties. UBB has plans to produce 100 million litres of biodiesel. Here the government is using the joint forest management model on un-irrigated degraded forest lands. In Andhra Pradesh (AP), the government created the Department of Rain Shadow Areas Development (RSAD) and has put RSAD in charge of large scale *Jatropha* plantations which the government has introduced. AP government has also announced a major subsidy package to all farmers for installing drip irrigation systems.[39] The government has taken a major initiative in introducing agreements between farmers, the private sector and the state biodiesel board. To protect the interest of the farmers, the government has reduced Value Added Tax on biodiesel to 4 per cent.[40]

At the central government level, the NMB and the Biodiesel Purchase Policy[41] have been undertaken to promote biodiesel. The MoPNG notification on Biodiesel Purchase Policy provides for the purchase of biodiesel by oil marketing companies at the rate of Rs 25 per litre (inclusive of taxes/duties/transportation cost) with effect from 1 January 2006. This is expected to start in about 20 purchase centres in 12 states. The suppliers should have the capacity to supply a minimum 10KL per tanker of biodiesel thereby meeting the prescribed specifications of the Bureau of Indian Standards (BIS)[42] and should be registered with the state level coordinator of oil companies. The blending of biodiesel at a maximum of 5 per cent will be undertaken initially at these 20 centres depending on the availability.

The Planning Commission study supported by the National Mission of Biodiesel (NMB) Report envisions far-reaching changes in the legal scenario to accommodate the biodiesel programme in the country. But at this point of time, when the whole initiative is at the experimentation stage, both the Planning Commission Report[43] and the NMB Report opines that presently the scope of biofuels could very well be integrated under the ambit of the existing laws. When the country is well positioned in the context of biofuels, it should have a separate legal mechanism in the form of Biofuels Act or Alternative Fuels Act. The following sections explain the legal amendments and the regulatory mechanisms suggested by the Planning Commission to promote the use of *Jatropha* based biodiesel.

The scope of the Weights and Measures Act, 1976 defines any goods for its characteristics in India that relate to inter-state trade or commerce in weights, measures and other goods which are sold or distributed by weight, measure or number. The Planning Commission recommends that the biofuels constituents like biodiesel and bioethanol being new products need to be defined for their characteristics under the Weights and Measures Act.[44] With regard to the procurement of raw materials, the report identifies that legal changes should take into account two factors for the promotion of the *Jatropha* and *Pongamia* plantation. First, there should be a provision for listing these raw materials under the category of cash crops which would nationally and internationally build an identity as a plant of some commercial value and second the government must set a procurement price for *Jatropha* and *Pongamia* seeds, as this would give the required incentives to farmers.

As far as licensing is concerned, it is clear that the oil marketing companies will be responsible for the procurement, whereas under the NMB it is recommended that the government issues licences in order to regulate the production and distribution of biodiesel in accordance with the Motor Sprit and High Speed Diesel (Regulation of Supply and Distribution and Prevention of Malpractice's) Order 1998[45] where the rules and guidelines are laid down for the issuance, renewal and cancellation of the licence given with respect to maintaining blend quality and avoiding adulteration. The Prevention of Food Adulteration Act, 1954 and Bureau of Indian Standards Act, 1986 are also required to incorporate these requisites so as to maintain the quality of edible oils. With regard to maintaining environmental and in particular adherence to Bharat/Euro emission norms, suitable amendments to the Environmental Protection Act, 1986 and the Motor Vehicles Act, 1988 and the rules framed needs to be incorporated to meet the required levels of standards or discharge from biodiesel engines.

Since *Jatropha* oil is being mixed with diesel, it will have to be recognized as an essential commodity to be protected under any circumstances. Considering this the government is planning to notify *Jatropha*/ biodiesel as a new category under the Essential Commodities Act, 1955. This gives the power to control production, supply, distribution, etc. of essential commodities for maintaining or increasing supplies and for securing their equitable distribution and availability at fair prices. In order to prevent unethical trade practices like hoarding and black-marketing in either *Jatropha* oil or biodiesel, it is being considered to include the biodiesel category under the Prevention of Black-marketing of Supplies of Essential Commodities, Act, 1980 to detain persons whose activities are found to be prejudicial to the maintenance of supplies.

With the understanding that tax incentives will benefit the interests of various stakeholders, the Planning Commission report has laid down clear mandates to provide an adequate subsidy programme and tax incentives. Since the programme is new in India, it is important that the biofuels programme gets sufficient support from the government. Keeping this in view, the government plans to tread carefully after the controversy with regard to the Ethanol Blending Programme. Among various tax incentives that are planned are included the deduction or waiver of excise duty, state and local taxes, and also the provision of adequate subsidies.

As far as an integrated biofuels programme is concerned, there has not been a legal push till date to promote biofuels on a large scale and in a sustained way. Different States in India have initiated their own ways to promote biofuels.

Philippines

The Philippines has launched the use of biodiesel, particularly a form of biodiesel known as Coco Methyl Ester or CME. This is a derivative of coconut oil and is commonly called Coco-biodiesel. The drive to switch over to an alternative source of fuel would harness a number of Philippines country strengths, while easing some of the burdens at the same time. The Philippines is the world's second largest producer of

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coconuts and a move to increase the usage of Coco-biodiesel would provide and establish a long-term, sustainable alternative domestic market and as a result, will stabilize the domestic coconut production, resulting in raising the price of copra. It would also enhance farm-based reintegration of opportunities.[46]

Increased dependence on Coco-biodiesel would also mean the enhancement of energy supply security through the use of indigenous resources, at the same time resulting in foreign exchange savings. Furthermore, the move would also benefit 3.5 million coconut farmers and 20 million Filipinos dependent on the coconut industry.[47]

The Department of Energy Act of 1992, declares the energy policy of the State as.

> "... to ensure a continuous, adequate and economic supply of energy in view of ultimately achieving self-reliance in the country's energy requirements through the integrated and intensive exploration, production, management and development of the country's indigenous energy resources, without sacrificing ecological concerns."[48]

Though the use and promotion of biofuels can be implicitly read into Section 2 (a) of the Department of Energy Act, the first concrete instrument in the Philippines to promote biofuels as a source of alternative fuel supply is the Memorandum Circular No. 55 issued by the Office of the President on 9 February 2004. Section 1 of this Memorandum Circular directs all departments, bureaus, offices, agencies and instrumentalities of the government, including government owned and controlled corporations to incorporate the use of one per cent by volume CME in their diesel requirements. The Memorandum Circular designates the Department of Energy (DOE) as the lead implementing agency for the CME Diesel Programme.[49] Section 4 of the Memorandum also mandates the Department of Energy to formulate the rules and regulations to give effect to the Memorandum Circular. To further supplement the CME Diesel drive, the Philippine Coconut Authority (PCA) is directed to include in its national programme for the coconut industry, the development of the supply chain for CME. The PCA, in consultation/coordination with other government agencies and the private sector, is also mandated to formulate a programme to encourage investment and technology for the production of CME to meet the needs of the domestic market.[50] The Memorandum Circular is vested with overriding powers and all orders, issuances, rules and regulations or parts thereof, which are inconsistent with the Circular, are stated to be repealed or modified accordingly.[51]

Pursuant to Section 4 of the Memorandum Circular, the Department of Energy formulated the Rules and Regulations implementing the Memorandum Circular. The Rules and Regulations serve as a comprehensive guideline for the implementation of the objectives of the Memorandum Circular. It empowers various agencies and prescribes their functions for the successful implementation of the CME Diesel Programme.

The Department of Transport and Communication (DOTC) is mandated to monitor and test emissions of the State owned CME Diesel run vehicles and submit reports of the same to the DOE.[52]

The Department of Environment and Natural Resources has the function of coordinating with the DOTC and DOE in terms of data generation of the results of emission testing using CME.[53] This data is to serve as an input in the emission standard-setting necessary to maintain air quality.

The Department of Science and Technology (DOST) coordinates and provides support on research and development works to do with the production and application of CME being undertaken by the academe, research institutions and others.

The Department of Trade and Industry is empowered to provide incentives to investment on CME production and coconut processing for the biodiesel industry. The Department of Finance is directed to develop and recommend appropriate fiscal and non-fiscal incentives for participating petroleum and oleochemical companies to promote the sustainable development of the CME Diesel programme.

The Philippine Coconut Authority (PCA) has assumed, in partnership with the coconut farmers, processors, refiners and traders, the further responsibility of ensuring the security of coconut oil supply by undertaking an aggressive programme for planting, replanting, fertilization, agricultural research and development, and rehabilitation of the coconut industry. To this end, the Rules and Regulations require the PCA to formulate a programme to encourage investments and technology for the production of CME to meet the needs of the domestic market.

The other landmark achieved by the Philippines is the passing of a Biofuel Bill by the House of Representatives. It has been forwarded to the Senate for final approval after which the Bill would become law. The "Bioethanol Fuel Act of 2005"[54] which has been pushed forward by the Committee on Energy of the House of Representatives was notified as an urgent measure by President Arroyo post the soaring crude oil prices in the international market. The full title of the original Bill reads "an Act mandating the use of bioethanol or ethyl alcohol as transport fuel, establishing for the purpose the National Bioethanol Fuel Programme, appropriating funds thereof, and for other purposes."

The Bill mandates the Department of Energy to adopt a National Bioethanol Fuel Programme that will implement a mandated blending of gasoline with bioethanol as a motor fuel.The DOE is also directed to gradually phase out "harmful gasoline additives and oxygenates" within six months after the law comes into effect. Gasoline that still contains these additives or oxygenates and gasohol (the gasoline-bioethanol blend) that do not follow the mandated mixture will be confiscated by the DOE.[55]

The Bill also provides fiscal incentives to encourage fuel production. These include exemption from paying tariff and duties on imports of inputs, machinery and equipment for 10 years, and a tax rating of bioethanol fuel equivalent to unleaded gasoline that shall remain for 10 years.[56]

The Bill[57] was revised by the House of Representatives to provide for policy support for the development of biofuels, other than bioethanol. Now that policy support is also accorded to other biofuels, the national programme has been re-christened the National Biofuels Programme.[58]

The Bill mandates the constitution of an independent board called the National Biofuels Board. The initial proposal of the Bill was to have the percentage blend directly increased from the given per cent to 10 per cent by the end of the fourth year of the approval of the law. The revised Bill would assign the National Biofuels Board, comprising of both private and government offices, including high-level representatives of the Department of Labour and Employment and the Philippine Coconut Authority, the function of recommending an increase in the minimum blend every two years. The Board will also have the power to determine and recommend a higher limit in terms of percentage of the fuel ethanol blended into gasoline. The Board also has the additional function of formulating a national programme for biofuels other than bioethanol.[59]

Another Bill that is pending before the Committee on Energy of the House of Representatives is the "Biodiesel Act of 2005".[60] The full title of this Bill reads "an act requiring the pre-blend of locally-produced methyl ester into diesel fuel to promote clean air and boost resource development for renewable fuels to reduce import dependence, open new export revenue, and provide fuel security for the country in times of global fuel shortage." The Bill seeks to harness coco methyl ester as a diesel enhancer to address air pollution, boost resource development as well as the rural economy, reduce oil import and accelerate the development of locally sourced renewable fuel.

Though the Bill has a long way to go before it reaches the Senate, the same would be a valuable support for the country's nascent Coco-biodiesel efforts.

Thailand

Rising oil prices have dealt Thailand's economy a major blow in 2005. Inflation is at a seven-year high, the current account is running deeply in deficit after years of surpluses, and the growth rate of the economy in 2005 is at its slowest in four years. The country is heavily dependent on oil imports. At 10 per cent of the GDP, they are up from the previous peak in 1980 of 8.0 per cent of GDP, and are four to five times the oil import bills of developed economies.[61]

While most countries have few options, but to put up with the huge import bill when it comes to soaring oil prices, Thailand is fast developing gasohol, a blend of gasoline and plant-based ethanol. Thailand is the world's top producer and exporter of tapioca, and its second-biggest sugar exporter, two crops in demand for the production of ethanol.

The major legislation in Thailand dealing with the subject of energy is The Energy Development and Promotion Act, 1992. An indirect reference to the subject of biofuels and their promotion can be found in this Act. Under the Act, one of the duties of the Department of Energy Development and Promotion is, *inter alia,* to maintain production and transformation of energy sources and the utilization of biomass to produce fuels.[62]

The Ministry of Energy (MoEN) through the Department of Alternative Energy Development and Efficiency (DEDE) has developed a Gasohol Strategy. The MoEN along with the Ministry of Agriculture and Cooperatives and the Ministry of Industry jointly proposed the Gasohol Strategy to the Cabinet in December 2003. The primary objective of the Gasohol Strategy was to create sustainable energy security for the country and its communities, to enhance the potential of communities to be energy production sources and to support the development of a domestic bio-chemical industry.[63] The Gasohol Strategy was adopted by a Cabinet Resolution dated 9 December 2003. The MoEN set the target on using ethanol for MTBE substitution in gasoline 95 by 1 ml/d by 2006 and for oil substitution in gasoline 91 for 3 ml/d by 2011.[64]

Through a Cabinet Resolution adopted on 18 May 2004, the Gasohol Strategy was further structured into two phases. Phase I, called the MTBE Replacement Phase, involves imposing the policy to terminate the use of MTBE in ULG 95 and replacing it with Gasohol 95 in some areas. Phase II of the Strategy, called the Gasohol Mandate Phase consists of notifying the list of cars capable of gasohol use, identifying the specification of Gasohol 91 and 95, and issuing regulations to the government agencies for the procurement of gasohol fuelled cars. The final stage of the Gasohol Mandate Phase involves the enforcement of the policy to use Gasohol 95 and 91 across the country.[65]

More specific steps in the direction of biofuels are the various implementations by the Ministry of Energy (MoEN) in support of the development of gasohol as a source alternative fuel. The MoEN has issued documents to every ministry for their support in the gasohol programme by directing all the government and state enterprise vehicles to use gasohol. This direction was dated 9 June 2004 with a requirement that every organization should file a monthly report of its target results in gasohol use.[66]

MoEN has issued a document to the National Supply Board at the Office of Prime Minister and Bureau of the Budget dated 9 June 2004 to determine the specification of cars to be procured in the fiscal year 2005 with a capability of being fuelled by gasohol. The Department of Energy Business (DEB) has announced the requirements in Gasohol Specification (No.3), 2004 with an effective date on 15 November 2004 for the specification of both gasohol 95 and gasohol 91.[67]

MoEN has reduced the remittance to the Oil Fund and the Energy Conservation and Promotion Fund, including the excise tax exemption, thus reducing the price of gasohol from that of gasoline 95 by 0.75 baht effective from 1 November 2004. The Cabinet has accepted a proposal of the MoEN to replace gasoline 95 with gasohol 95 in all gas stations within Bangkok.[68]

The DEB invited the gasohol producers and distributors for a meeting to update them about the gasohol promotion schemes of the

MoEN and for hearing any problems that might occur in that implementation. The Energy Policy and Planning Office brought together the ethanol producers and the Refinery Group to have a discussion on an ethanol-purchasing price for a long run of 3-6 months and for instition of an arrangement in the form of a long-term ethanol-purchasing contract.[69]

MoEN and the Ministry of Industry jointly agreed on 24 December 2004 to replace the National Ethanol Board with the National Biofuel Promotion Board for the better organization, regulation, supervision and the determination of policy for the biofuel industry. This aims to make the fuel operations a national agenda with an effective implementation for both ethanol and biodiesel and an integrated operation, starting from raw material, factory establishment, production, blending and distribution of gasohol, including the selling price determination.[70]

On 11 April 2005, The National Energy Policy Board issued an Order No. 3/2005 to appoint the Biofuel Promotion and development Committee to establish the Plan and Policy on the administration and development of the country biofuels. This would be a focal point in policy determination, supervision, regulation and promotion of biofuels. On 19 April 2005, based on a proposal by the MoEN, the Cabinet agreed to reduce the Oil Fund burden by pushing forward the gasohol use promotion schemes, i.e. using 4 ml/d of gasohol and speeding up the increasing of gasohol stations from 800 to 4000 stations by the end of 2005. A strict order was issued to comply with the Cabinet Resolution dated 9 December 2003, which resolved to use gasohol in all government and state enterprises vehicles. A requirement was also imposed on the 413 gas stations located within the government and state enterprise campuses to sell only gasohol.[71]

MoEN has determined the measures to support and promote the use of biofuel, especially gasohol by increasing the pricing difference between gasoline and gasohol by 1.50 baht per litre and increasing the remittance to the Oil Fund by 0.05 baht per litre.

Biodiesel initiatives in Thailand are still in various experimental project stages, though there is a Cabinet Resolution dated 18 January, 2005 targeting the commencement of commercial biodiesel distribution by 2006 and to increase the biodiesel percentage in blends by up to 10 per cent by 2012.[72]

Malaysia

Malaysia, the world's largest producer of palm oil, is moving in the direction of initiatives for the use of palm biodiesel. The government unveiled a National Biofuel Policy in August 2005. Which is primarily aimed at reducing the country's fuel import bill. This aims to promote further the demand for palm oil, which will be the primary commodity for biofuel production (alongside regular diesel), as well as to shore up the price of palm oil especially during periods of low export demand.[73]

The policy envisions a multi pronged strategy for the development of palm biodiesel as a commercial reality. This involves the production of a biodiesel fuel blend of 5 per cent processed palm oil with 95 per cent petroleum diesel. Simultaneously, the policy aims at encouraging the use of biofuel among the public. This means providing incentives for oil retail companies to supply biodiesel pumps at fuel stations. As a support measure, the policy also directs the establishment of industry standards for biodiesel quality. To ensure the smooth supply of biodiesel, the policy also calls for the setting up of new biodiesel plants.

A more significant development in Malaysia is a proposed legislation on biofuel use. The Commodities Ministry had formulated a Biofuel Plan in June 2005. This was approved by the Malaysian cabinet, the first step before the proposal can be taken to the Malaysian Parliament to make it law. Presently, the Bill is in the Malaysian Parliament and legislators are expected to make it law some time in 2006.

The Bill seeks to mandate the use of 5 per cent palm oil blend across the country by 2007. After the enactment of this law, unblended diesel would no longer be available in Malaysia. Prior to enforcement of this mandate in 2007, the Bill seeks to make biodiesel commercially available from 2006 in order to enable consumers to try out this blend.

As a preparatory measure to the mandatory use of biofuels in 2007, the Malaysian government plans to introduce biodiesel as the fuel source for the Defence, Plantations and Transport ministries starting early 2006. Selected public buses, taxis and army trucks and four-wheel drive vehicles will use biofuel, while palm oil millers will feed their generators and mills with the fuel. The interim trial period is to be used to identify any problems arising out of the large-scale use of biodiesel.[74]

Indonesia

Indonesia, the world's second-largest palm oil producer, is preparing a biofuel scheme for the next five years.[75] The Indonesian Agriculture Ministry has been studying a biofuel programme and plans to open plantations of *Jatropha* and palm in the future. Indonesia aims to boost crop area under palm plantations to 8 million hectares in the next three years from the current 5 million hectares. Indonesia is exploring the world biodiesel market as world palm oil demand stagnates.[76]

Japan

In 2003, Japan had introduced a law that allowed for the blending of ethanol with gasoline by up to 3 per cent. The Environment Ministry of Japan aimed to introduce gasoline containing 3 per cent bioethanol on the retail market by April 2005. For a country that consumes about 1.04 million barrels of gasoline a day, the government also has the ambitious plan to replace all retail gasoline by bioethanol blended fuel by 2012. Japan, a Kyoto Protocol leader expects this effort to cut carbon dioxide emissions by as much as 2 million tons a year.

This vision suffered a setback due to the failure of bioethanol blended gasoline to hit the market in 2005. Analysts are of the opinion that scarce availability of domestically produced bioethanol and possibly the heavy dependence on imports are the contributing factors for bioethanol not hitting the market.[77]

Japan, being the world's second largest gasoline consumer, would require a very large amount of bioethanol to replace 3 per cent of gasoline. Bioethanol blended gasoline facilities would require huge investments and the ambitious government policy would also create risks for the oil industry involving import costs and possible volatility in freight rates. Furthermore, the scarcity of domestically produced ethanol would mean that the huge requirement of ethanol to replace 3 per cent of gasoline would have to be imported. This would significantly add to the cost of blended gasoline as most of the ethanol import has to be from Brazil, which is geographically distant. Taking these factors into account, it is unlikely that bioethanol blended gasoline would hit the markets very soon.

China

Though China ranks third in the world in ethanol production, not much of it is used as fuel. The Chinese bioethanol fuel programmes are a product of the state sponsored five-year plans.[78] In February 2004, the government directed five provinces to blend 10 per cent bioethanol with the gasoline used in those provinces. These five provinces account for 16 per cent of all passenger vehicles in China. Another four provinces have been directed to promote the use of ethanol blended gasoline for trials. Presently, the government subsidizes ethanol production at four plants.[79] Though new ethanol plants are under construction, projections show that the demand for ethanol required for a 10 per cent blend for all cars in China would far exceed the projected supply even after taking into account all the present proposed initiatives.[80] At the same time biodiesel production in China is still at a very nascent stage.

To supplement the biofuels initiative and in general to give the production of renewable energy a boost, the National People's Congress of China recently enacted The Renewable Energy Law, 2005 which has come into force from 1 January 2006. The aim of this Law is to promote the development and utilization of renewable energy, improve the energy structure, diversify energy supplies, safeguard energy security, protect the environment, and realize the sustainable development of the economy and society.[81] The term renewable energy has been defined expansively to include, *inter alia,* biomass energy[82] and Article 32 of the Law specifically defines 'biological liquid fuels' to include methanol, ethanol, biodiesel and other liquid fuels that may be derived from biomass resources.

Through this Law, the Government of China lists the utilization development of renewable energy as the preferential area for energy development and promotes the construction and development of the renewable energy market by establishing total volume for the development of renewable energy and taking corresponding measures.[83] Furthermore, the government encourages economic entities of all ownerships to participate in the development and utilization of renewable energy and protects the legal rights and interests of the developers and users of renewable energy on the basis of law.[84]

The energy authorities of the State Council are responsible for carrying out renewable energy resource surveys and to formulate technical regulations for the same.[85] They are also responsible for the setting up of long- and medium-term targets for the development and utilization of renewable energy at the national level.[86] On the basis of these targets and taking into account, the economic development and the actual situation of renewable energy resources at the regional level, the State Council is to coordinate with the government at a regional level for the setting up of long- and medium-term targets for the provinces and other regions.[87]

The Law mandates the energy authorities of the State Council to prepare a national renewable energy development and utilization plan on the basis of the renewable energy targets.[88] At the provincial level, this responsibility falls on the energy authorities of the provincial government.[89]

The energy authorities of the State Council are also mandated to frame development guidance catalogues for renewable energy industries.[90] The standardization authorities of the State Council have the mandate to set technical standards for renewable energy technology and products.[91]

The Government of China encourages clean and efficient development and utilization of biological fuel and encourages the development of energy crops.[92]

The Law specifically encourages the production and utilization of biological liquid fuel.[93] Gas-selling enterprises are mandated, on the basis of the regulations of the energy authorities of the State Council or the government at the provincial level, to include biological liquid fuel conforming to the national standard into its fuel-selling system.[94] Failure by a gas selling enterprise to include biological liquid fuel that conforms to the national standard into its fuel selling system and thus causing economic loss to the biological liquid producing fuel enterprise would make the former liable to pay compensation.[95] Any further non-compliance of corrective directions issued by the State Council or the provincial government to include biological liquid fuel would attract an additional fine up to the amount of economic loss caused by such non-inclusion.[96]

The Law provides a significant boost to the development, utilization and promotion of renewable energy by listing scientific and technical research in the development and utilization, and the industrialized development of renewable energy as the preferential area for hi-tech development and hi-tech industrial development in the national programme. It allocates funding for the scientific and technical research, application demonstration and industrialized development of the development and utilization of renewable energy so as to promote technical advancement in the development and utilization of renewable energy, reduce the production cost of renewable energy products and improve the quality of the products.[97]

The Law also constitutes the renewable energy development fund for supporting scientific and technological research, standard establishment and pilot projects for the development and utilization of renewable energy,[98] construction of renewable energy projects for domestic use in rural and pasturing areas,[99] construction of independent renewable power systems in remote areas and islands,[100] surveys, assessments of renewable energy resources, and the construction of relevant information systems,[101] and localized production of the equipment for the development and utilization of renewable energy.[102]

The Law permits financial institutions to offer preferential loans with financial interest subsidy to renewable energy development and utilization projects that are listed in the national renewable energy industrial development guidance catalogue and that conform to the conditions for granting loans.[103] Even before the enactment of this Law, some renewable projects had already received such loans under a circular called the "Circular Regarding Issues on Further Supporting the Development of Renewable Energy, 1999" that was published in January 1999 by the National Reform and Development Commission and the Ministry of Science.[104] The Law also provides tax benefits to projects listed in the renewable energy industrial development guidance catalogue, and specific methods for the granting of these benefits are to be prepared by the State Council.[105]

Conclusion

The important issue that has to be discussed is the need to have a biofuels legal regime. It is pertinent to note that the recent set of biofuels initiatives have been motivated by record highs in the international oil prices. Only at this sustained high price level would biofuels become an economically viable alternative. The corollary would also mean that the easing of oil prices would significantly affect the infant biofuel ventures.

There is a pressing need to support biofuel ventures as, apart from the environmental benefits, specifically in the Asian context biofuels also persent the possible solution for energy security through diversification, and rural energization and employment. Even if oil prices come down, thus making biofuel alternatives relatively costly in the short run, the shortage of crude oil supply is an inevitability that has to be faced at some point. The raw materials needed for the biofuel industry being a product of the rural economy, biofuel ventures in Asia revolve around the active participations of the rural populations.

For these reasons, a strong legal regime supporting biofuel initiatives is necessary. There should be a legal mandate for the compulsory blending of biofuels with regular fuels. This would create a market for biofuels. To facilitate the entry of more players in the biofuel industry and to ensure the uninterrupted supply of biofuels, the production of the same should be made economically viable. Thus the law should also provide for various tax breaks and subsidies. Once the biofuel industry attains the economies of scale to be self-sustaining, these incentives can be gradually withdrawn.

Thus a legal regime for biofuels is not only a necessity, but it is also a prudent measure that cannot fail to provide benefits.

End Notes

[1] The Brazilian National Programme of Fuel Alcohol (PROALCOOL) of 1975, promoted the production of sugarcane ethanol to overcome the oil shock. The programme mandated blending of sugar ethanol to gasoline (20-26% vol.). By 2005, the programme became fully competitive to gasoline after phasing out support mechanisms. In 2004, 14.8 Mm3 produced, 2.5 bln litres exported accounting saving of 35.1 Mt CO2 eq (~ 14% of national CO2 emissions from fossil fuels). (Unica - São Paulo Sugarcane Agroindustry Union and also Lucon, Oswaldo, 2005) The success of PROALCOOL was due to: (1) close coordination among all sectors involved, the various ministries, the automobile industry, PETROBRÁS (state owned oil company), the fuel distributors, and the gas stations, and the consumers and (2) the creation of subsidies to stimulate the production and purchase of hydrated alcohol run cars. The reduction of the tax on industrialized products (IPI) also played a major role in this context. http://brazilembassyinindia.com/proalcool.htm (accessed on Jan 04, 2005).

[2] (a) Ministry of Agriculture, Livestock, and Supply, Government of Brazil launched the National Agro-energy Plan on 14 October 2005. The initiative is part of the government's effort to increase biofuel production. Beginning in 2008, a 2 % mixture of biodiesel with regular diesel fuel will become mandatory in Brazil. This represents an annual consumption of nearly 1 billion litres of biodiesel. (Alexander's 's Oil and Gas Connections, 2005).

(b) From 2008, Brazilian oil companies will have to add at least 2 per cent biodiesel to regular diesel and from 2012, this percentage will rise to 5 per cent. This will act as an incentive to industries to develop profitable ways of using biodiesel and for farmers to produce more to meet the internal demand. (Osse, Sergio 2005)

[3] Supra note 1.

[4] In United States, state governments have taken the initiative in a large way by introducing biofuels (biodiesel and ethanol mixing) legislations.

[5] European Union Biofuels Directive (2003/30/EC) lays down guidelines to expand the production and use of biofuels derived from agricultural, forestry and organic waste products. The directive sets only indicative targets and not mandatoray targets. The target for 2005 is 2% of transportation fuel and 5.75% by 2010. Thus, as per the Biofuels directive member states should ensure that a minimum proportion of biofuels and other renewable fuels is placed on their market. If the objectives set in the directive are achieved, the consumption of biofuels in the EU will increase from 1.4 mill. tons oil equivalents in 2001 to 19 mill. tons in 2010. The Energy tax directive (2003/96/EC, 27.10.2003), gives the possibility to member states to grant tax reductions/exemptions in favour of biofuels, under certain strict conditions. The exemption or reduction in taxation applied by member states must be adjusted to take account of changes in raw material prices to avoid over-compensation.

[6] Osse, Sergio, 2005.

[7] 22 of the last 31 Nuclear Power Plants (NPPs) connected to an energy grid were in Asia, and 18 of the 27 NPPs presently under construction are in Asia (IAEA Study 2004).

[8] A good example is the case of the number of important biofuels technology as well as marketing players investing in Asian and African countries.

[9] Goldman Sachs, 2003.

[10] UNDP, 2003. *World Urbanization Prospects: The 2003 Revision Population Database*, United Nations Population Division (http://esa.un.org/unup/index.asp?panel=3) Assessed December 21, 2005.

[11] EIA 2003. *International Energy Outlook.*

[12] IEA 2002. World Energy Outlook.

[13] *World Energy Outlook*, 2002, Also see Ram Mohan and Kumar, 2005 and *Report of the Committee on Development of Biofuels*, Planning Commission, Government of India, 2003. More, see http://envfor.nic.in/naeb/sch/wsl/wsl.html

[14] Ministry of Environment and Forests (MoEF), Government of India initiated the National Wastelands Identification Project (NWIP) in collaboration with the National Remote Sensing Agency and the Survey of India to prepare district-wise wastelands maps on 1:50,000 scale by using satellite data. Wastelands maps for 146 districts have been prepared and distributed to the concerned State and district level agencies. Maps for 91 districts are under preparation. Selection of these districts is based on the criterion that 5% or more of the geographical area of these districts is estimated to be wastelands.

[15] (a) Kalam, A P J Abdul 2005 http://presidentofindia.nic.in/scripts/eventslatest1.jsp?id=991 Assessed 24th December 2005.
(b) The Auto Fuel Policy announced by Government of India also recommends the use of biofuel to cut harmful vehicular emissions by almost 50 per cent. Mashelkar 2002. Report of the Expert Committee on Auto Fuel Policy, 2002.

[16] Ram Mohan and Kumar, 2005 also Kher, Rajeev, 2005.

[17] *Ibid.*

[18] The *Power Alcohol Act* was repealed as per the recommendation of the P C Jain Committee which was appointed to recommend the scraping of laws that serve no purpose.

[19] Section 6, The *Indian Power Alcohol Act, 1948.*

[20] Discussion on Indian Power Alcohol (Repeal) Bill, 2000. (Bill Passed) (XIII LOK SABHA debates).

[21] Section 2 (c), The *Indian Power Alcohol, 1948.*

[22] The Gazette Of India: Extraordinary [Part I- Sec. I], Ministry Of Petroleum And Natural Gas Resolution, New Delhi, 3 September 2002 No. P-45018/28/2000-C.

[23] The areas that have been notified are the States of Goa, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Uttar Pradesh, Uttaranchal, Andhra Pradesh (all districts except Chittoor and Nellore), Tamil Nadu (only districts — Coimbatore, Dindigul, Erode, Kanyakumari; Nilgiri, Ramanathpuram, Tirunelveli, Tuticorin, and Virudhunagar), and the Union Territories of Chandigarh, Dadra & Nagar Haveli and Daman & Diu.

[24] XIV Lok Sabha Debates, Question to the Minister of Petroluem and Natural Gas to the situation arising out of the withdrawal of mandatory order regarding mixing of 5% of ethanol in petrol and subsidy of 30 paise per litre given to the ethanol.

[25] *Ibid.*

[26] *Ibid.*

[27] *Ibid.*

[28] *Fifth Report, Standing Committee On Petroleum & Natural Gas (2004-05)*, (Fourteenth Lok Sabha) Ministry Of Petroleum & Natural Gas, Lok Sabha Secretariat, New Delhi, April, 2005.

[29] Supra note 24.
[30] Supra note 22.
[31] Supra note 28.
[32] *Report of the Committee on Development of Biofuels*, Planning Commission 2003.
[33] Biodiesel Purchase Policy, Ministry of Petroleum and Natural Gas, Government of India, 9 October 2005.
[34] Lohia, A. K. 2005.
[35] Duhera, Rolly, 2005.
[36] Prasad, Manohara, 2005.
[37] Supra note 35.
[38] Supra note 34.
[39] Supra note 36.
[40] Supra note 36.
[41] See supra notes 22, 32.
[42] The Bureau of Indian Standards, empowered through a legislative Act of the Indian Parliament, known as the *Bureau of Indian Standards Act, 1986*, operates a product certification scheme. The BIS product certification scheme is essentially voluntary in nature, which allows the licensees to use the popular ISI Mark, and is largely based on ISO Guide 28.
[43] Supra note 32
[44] Detailed Project Report, National Mission on Biodiesel, Ministry of Rural Development, Government of India (2004).
[45] Ministry of Petroleum And Natural Gas Order, New Delhi, 28th December, 1998 GSR 772 (E).- Order made by the Central Government in exercise of the powers conferred by Section 3 of the *Essential Commodities Act, 1955*(Central Act 10 of 1955).
[46] http://www.doe.gov.ph/alternative/cme.htm
[47] *Ibid.*
[48] Section 2 (a), *Department of Energy Act, 1992.*
[49] Section 2, Memorandum Circular No. 55. Office of the President of the Philippines, dated 9 February 2004.
[50] Section 3, Memorandum Circular No. 55. Office of the President of the Philippines, dated 9 February 2004.
[51] Section 6, Memorandum Circular No. 55. Office of the President of the Philippines, dated 9 February 2004.
[52] Section 5, Rules and Regulations Implementing Memorandum Circular no. 55.
[53] *Ibid.*
[54] House of Representatives Bill No: HB 04629.
[55] Yap, Arthur 2005 http://www.iea.org/Textbase/work/2005/Biofuels/Biofuels_Yap_Presentation.pdf
[56] Ho, Abigail L 2005, http://money.inq7.net/topstories/view_topstories.php?yyyy=2005&mon=11&dd=09&file=3.
[57] This is a Bill sponsored by Representative Juan Miguel Zubiri.
[58] Reyes, Mary Ann L., 2005.
[59] *Ibid.*
[60] House of Representatives Bill No: HB 04341
[61] "Thailand looks to biofuels to ease economic pain". *The Financial Express*, Bangladesh, 21 November 2005, http://financialexpress-bd.com/index3.asp?cnd=11/21/2005&section_id=4&newsid=7391&spcl=no
[62] Section 6 (6), The *Energy Development and Promotion Act, 1992.*
[63] Policy on Alternative Energy by Ethanol, Department of Alternative Energy Development and Efficiency, Ministry of Energy, Thailand (2005).
[64] *Ibid.*
[65] *Ibid.*

[66] Promotion on Ethanol Use, Department of Alternative Energy Development and Efficiency, Ministry of Energy, Thailand (2005).

[67] *Ibid.*

[68] Cabinet Resolution RE: The Promotion of Gasohol through the Gas Stations within Bangkok, dated 2 November, 2004.

[69] *Ibid.*

[70] *Ibid.*

[71] *Ibid.*

[72] Biodiesel, Department of Alternative Energy Development and Efficiency, Ministry of Energy, Thailand.

[73] http://www.bcb.com.my/corporate_info/pdf/Aug05/Vol%203%202005%20Ind%20Issue%20biofuel%20policy%20081205.pdf

[74] http://english.people.com.cn/200512/25/eng20051225_230698.html

[75] http://www.planetark.com/dailynewsstory.cfm/newsid/33161/story.htm

[76] http://www.planetark.com/dailynewsstory.cfm/newsid/31182/story.htm

[77] http://www.planetark.com/dailynewsstory.cfm/newsid/31592/story.htm

[78] Moore, Janet 2005 http://www.startribune.com/117/story/73696.html

[79] http://www.planetark.com/dailynewsstory.cfm/newsid/31182/story.htm

[80] Slingerland and Geuns 2005.

[81] Article 1, The Renewable Energy Law, 2005.

[82] Article 2, The Renewable Energy Law, 2005.

[83] Article 4, The Renewable Energy Law, 2005.

[84] *Ibid.*

[85] Article 6, The Renewable Energy Law, 2005.

[86] Article 7, The Renewable Energy Law, 2005.

[87] *Ibid.*

[88] Article 8, The Renewable Energy Law, 2005.

[89] *Ibid.*

[90] Article 10, The Renewable Energy Law, 2005.

[91] Article 11, The Renewable Energy Law, 2005.

[92] Article 16, The Renewable Energy Law, 2005.

[93] *Ibid.*

[94] *Ibid.*

[95] Article 31, The Renewable Energy Law, 2005.

[96] *Ibid.*

[97] Article 12, The Renewable Energy Law, 2005.

[98] Article 24 (1), The Renewable Energy Law, 2005.

[99] Article 24 (2), The Renewable Energy Law, 2005.

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[101] Article 24 (4), The Renewable Energy Law, 2005.

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Biofuels and WTO: An Emerging Context

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Abstract: Biofuels are strongly emerging as partial substitutes for fossil fuel and this has an economic as well as environmental angle. Sooner or later, the trade angle of the biofuel sector is likely to feature in international discussions and at that time, we may have to look into the arguments that focus on trade that is associated with environmental issues. At Doha, in the Ministerial meeting under Para 51, the issue emerged though indirectly, but the literature emerging from developed countries suggests that the arguments will surface on four counts. First, it will feature in the market access context from the point of view of the net exportable countries. Second, the support measures to the farmers will get into the discussions especially in the context of comparison between developed and developing countries. These steps will provide an opportunity to some of the developed countries to push their sizeable farm subsidies under the non-actionable group putting forth the biofuel front. That will have a bearing on the Hong Kong agreement. Third, the debate may emerge in the context of technical barriers to trade as the technologies are well developed by a few countries. Lastly, the biofuel sector may also cause a flutter in the context of the neglected interface between environmental agreements (Kyoto Protocol) and WTO. This paper is only indicative of the forthcoming arguments as the use rates of biofuels are still quite low but raises a few intriguing questions.

Introduction

Biofuels are preferred the world over as partial substitutes to traditional fossil fuels on two major counts. First, this is a renewable fuel with least environmental externalities. Second, it is economically viable and associated with strong income transfer effects. Biofuels are now set to become the most acceptable substitute owing to the environmental advantages and economic acceptance. A number of questions are however, raised in this context. Biofuels save on the traditional fossil fuels and this will have a bearing on the trade sector. It is known that most developed and developing countries spend a huge amount of

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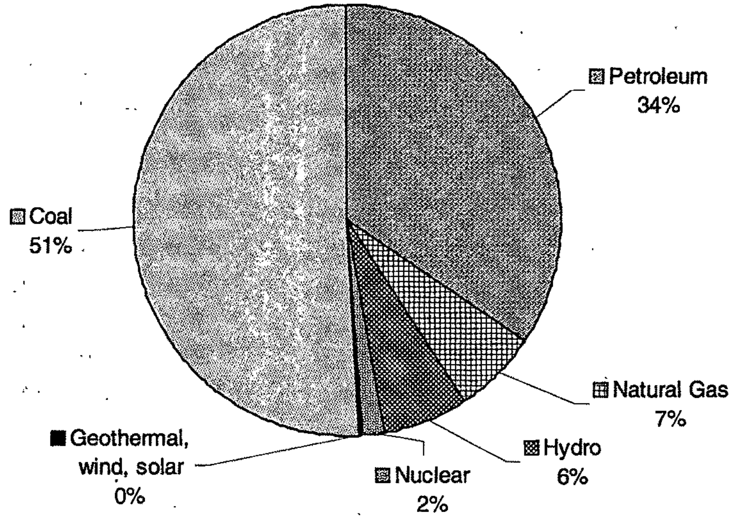
foreign exchange on oil imports. Therefore, these countries would like to introduce the use of biofuels aggressively by cutting down the cost of production and subsidizing the same. The effect of these measures will impact aggregate trade, trade related issues therefore will come into play. It is now a well-accepted fact that biofuels have lower environmental externalities and are acceptable on well-acknowledged environmental standards. That brings in the issue of international environmental agreements and the increased use by environmentally conscious countries. Increased production and use of biofuels will be provided with incentives in the production sector and that will fetch in agreements on the aggregate measure of support. This paper is an attempt to discuss some of these issues keeping the Indian context at the core of the discussion. We are quite aware of the limitations of the data, of the literature in the Indian context and of the present low use rates. In such a situation some of these are distant consequences, but raising the issues on this platform is yet essential.

Biofuels and Energy Use

Biodiesel is one of the main components of biofuels. It was introduced in a few countries around World War II, to power vehicles and the interest was renewed in the recent past. Presently it is partially replacing the traditional fuel. Biofuel is an ester-based fuel oxygenate derived from renewable bio-resources such as *Pongemia Pennata, Jatropha curcas,* soybean, mustard, rapeseed, peanuts, other vegetable oils, and animal waste like beef tallow (Francis, George *et al.* 2005). It can be used in pure form but not advised due to the problem of Polymerisation (vegetable oils contain triglycerides that end up in high oil gumminess resulting in the formation of long saturated carbon chains) and therefore, is largely blended with petroleum diesel (petrodiesel) for use in compression-ignition (diesel) engines.[1] The rationale of blending biofuels with the fossil fuel rests on a few counts namely: (i) ethanol and biodiesel are less damaging from the environmental point of view due to the composition of the emission; (ii) it provides energy security in rural areas; (iii) it has a strong employment and income generating effect; (iv) the plants are soil enriching and help in arresting soil degradation; (v) its introduction answers the global concern about the greenhouse effects, and (vi) it reduces the dependence on huge oil imports and saves foreign exchange as well as reduces dependence on the oil exporting countries.[2]

Figure 1: India's Fuel Share of Energy Consumption, 2001 (Btu)



Source: EIA (2001).

In India, almost 90 per cent of the total energy consumption comes from fossil fuels (coal, petroleum and natural gas). Only 0.2 per cent of non-traditional sources are used. Among the fossil fuels, coal accounts for about 50 per cent of India's energy consumption. Petroleum is the second highest providing 34.4 per cent of energy consumption, while natural gas and hydroelectricity meet with 13 per cent of the consumption (see Figure 1). Recently, natural gas has grown in importance, as its share in India's energy consumption is rising. Non-conventional sources of energy like wind, solar energy, and biomass constitute a very small share of the country's energy consumption. It is a well-accepted fact that the markets for all fuels develop with the growth of the economy. This happens due to a circular causation. While the demand for infrastructure increases with production activities, these activities in turn create the need for additional infrastructure. That generates demand for fuel and fuel substitutes.

It is a well-accepted fact that fuel demand is largely dictated by lagged real GDP. The growth of the economy (represented by real GDP growth) is thus the main determinant of fuel demand. It is expected that Indian GDP will grow by more than 8 per cent per annum during the near future and it is also an agreed fact that the growth rate of demand for fuels in any country will be above half of that of Gross Domestic Product (GDP) growth. Our energy demand is therefore expected to grow at more than 5 per cent per annum owing to an increase in urbanization, standard of living, and expanding population. In India, the elasticity of fuel demand was 3.06 in the First Plan and peaked at 5.11 during the Third Plan. It came down to 1.65 in the eighties, but during the nineties, an elasticity of around 1.5 is projected in the near future (TERI *Report on Market assessment for fuel cells in India*). The market for biofuels will develop out of three important conditions. First, it is the shortage and price of the fossil fuels that will make it necessary to shift to an alternative. Second, the pollution created by the increased density of vehicles using traditional fossil fuels will make it obligatory to search for alternatives. Third, biofuels will automatically lead to more vegetation and use of forest, non-forest products apart from bringing in proper usage of waste lands.

Presently, our energy use is largely from the fossil fuels. While the country is short of petroleum reserves, it has large arable land as well as good climatic conditions (tropical with adequate rainfall in large parts of the area) to account for biomass production each year. That provides a good opportunity to shift towards this alternative source. The GDP-Fuel equation (Fuel demand explained by the lagged GDP) clearly shows that fuel demand is increasing at 4.30 per cent per annum between 1970-71 and 2002-03. Therefore, in order to support an envisaged growth of GDP at around 8 per cent per annum, the rate of growth of fuel supply

Table 1: Fuel Supply Overview

Component	Quantity
Proven Oil Reserves (1/1/04E)	5.4 billion barrels
Oil Production (2003E)	819,000 barrels per day (bbl/d),of which 660,000 bbl/d was crude oil
Oil Consumption (2003E):	2.2 million bbl/d
Net Oil Imports (2003E):	1.4 million bbl/d
Crude Oil Refining Capacity (1/1/04E)	2.1 million bbl/d
Natural Gas Reserves (1/1/04E)	30.1 trillion cubic feet (Tcf)
Natural Gas Production (2002E)	883 Bcf (Billion cubic feet)
Natural Gas Consumption (2002E)	883 Bcf
Recoverable Coal Reserves (2001E)	93.0 billion short tons
Coal Production (2002E)	393 million short tons (Mmst)
Coal Consumption (2002E)	421 Mmst
Net Coal Imports (2002E)	28 Mmst

Note: Units are mentioned with each component, Reference Year in Brackets.
Source: Data from www.indiastat.com

needs to be about 5 per cent annually. If experience is any indication of the fact that the present supply will not be able to meet the future demand of fuel by the year 2011-12. India may face severe fuel shortages, affecting all user sections such as transport, communication, as well as agriculture. But markets have still not developed for biofuels and the process is quite slow compared to the potential.

Biofuels and Emerging Markets

Among the well-established biofuels, ethanol is produced mainly from cane or molasses, generally a bi-product of the sugar industry, and thus is a renewable resource. It can also be produced from starch, potatoes and even wood. Similarly, oil is usable as biofuels and could be extracted from other oilseeds but as the demand for edible oil outpaces its supply, it is economically not viable to use edible oil for production of biodiesel. Alternatively, there are a few tree species, which produce seeds rich in fuel oil. Of these, some promising tree species are *Jatropha curcas* (Ratanjyot, Chandrajyot), *Simerouba Glauca* and *Pongamia pinnata* ('honge'or 'Karanja'), which are well established in India's climatic conditions. These are largely grown on cultivable wastelands, on degraded forest areas and could also be cultivated as a plantation as well as grown on the sides of railway tracks, roads and bunds of irrigation canals. Among various combinations of blended biodiesel, the most common combination is B-15 (15 per cent biodiesel with 85 per cent petro-diesel). B-15 has been designated as an alternative fuel. But as the biodiesel industry is still in an infant stage and assaying into full-fledged manufacturing processes, there are various compositions being used in actual practice. Several industries and commercial establishments such as hotels, hospitals and restaurants are already using some form of the alternative fuel and as such are potential customers for such fuels.

The demand for biofuels mainly emanates from vehicles that include all transportation vehicles. In India, the density of vehicles has been growing at a very rapid rate. The growth has been phenomenal during the nineties (see Figure 2). The increase in motor vehicles is phenomenal in the case of cars, jeeps, taxis and trucks. We can also see this from the growth rates of motor vehicles in the country (see Table 2). The demand for biofuels will be largely from buses and transport vehicles that are growing at 2.23 and 2.06 per cent per annum. Therefore, we can expect the biofuel sector to grow initially at above 8 per cent per

Table 2: Percentage Increase and the Growth Rate of the Types of Vehicles: 1980-81 to 2002-03

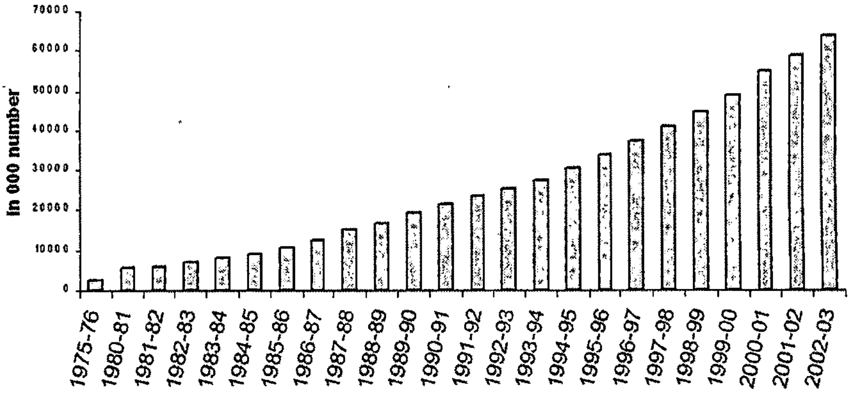
Types of Vehicles	Average (in 000 numbers) 1980-81 to 1989-90	1990-91 to 2002-03	% In]crease	Growth Rate (1990-91 to 2002-03
Two Wheelers	6572.70	27325.31	315.74	2.37
Cars, Jeeps & Taxis	1811.20	5037.38	178.12	2.59
Buses	225.90	495.23	119.23	2.23
Trucks	878.40	2256.15	156.85	2.06
Others	1474.10	4290.31	191.05	2.26
Total	10962.30	39404.38	259.45	2.36

Source: Data from www.indiastat.com

annum and to settle down in the neighbourhood of a 5 per cent growth rate per annum in the long run.

Increase in the density of motor vehicles could be visualized in five distinct phases. The first phase marks initial slow growth up to 1985-86, followed by the second phase that ended at 1990-91. The third phase began in 1990-91 and provides actually three distinct periods in that span of 12 years. What we can see from Figure 2 is the sharp growth after 1995. That culminated into a high incremental demand for petroleum products during nineties (see Figures 3 and 4). It can be seen from the table that increase in the consumption of petroleum products during the nineties has been phenomenally high. The change is substantial in Consumption of Liquid Petroleum Gas, Petrol Coke, High Speed Diesel Oil, Naptha and Motor Gasolene. In India, we may have to continue to depend on

Figure 2: All Types of Registered Motor Vehicles in India



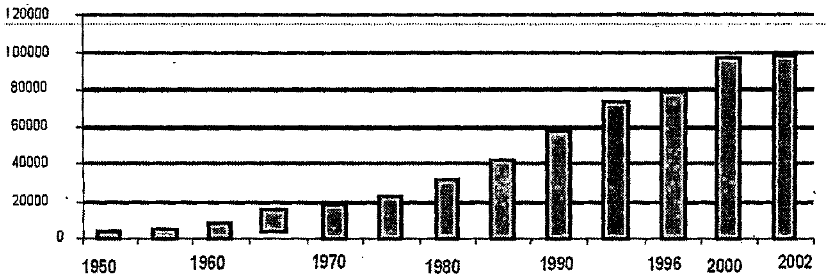


Figure 3: Total Sales/Consumption of Petroleum Products: India 1950-2002

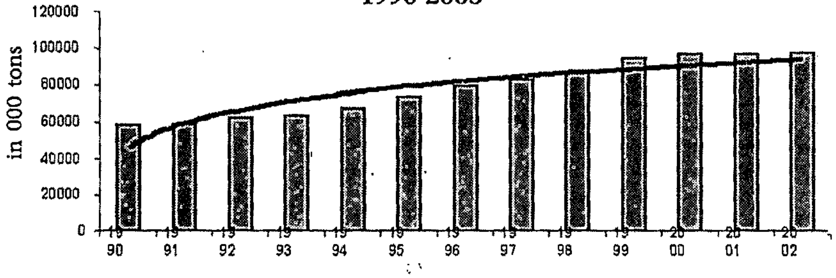


Figure 4: Total Sales/Consumption of Petroleum Products in India 1990-2003

the fossil fuels especially imports of petroleum products which is growing at the rate of 2.3 per cent per annum (see Table 3). That will force us to depend on international markets either for petroleum products or even for biofuels. This situation is globally similar and may worsen in the future as can be seen in Annexure Tables 1 and 2.

Biofuels could be used with petroleum in a combination of 85:15 with a few categories and thus at the present consumption level, the volume of market for biofuels works out to be 2.787 million tons. That demand is certainly too huge to be met with the ongoing programmes and thus there will be a little dent on the import bills. Our present production of crude oil from own sources is about 680 thousand barrels per day and that is fluctuating significantly, needless to add that this supports a very small portion of our demand.

Oil accounts for about one third of India's total energy consumption. India's major oil production facilities are located in Mumbai High, Upper Assam, Cambay, Krishna-Godavari, and Cauvery basins. The Mumbai High field is the largest oil reserve, with an output of around 2.6 lakh barrels per day (bbl/d). But that is way below the

Table 3: Per cent Increase and Growth of Petroleum Products 1970-71 to 2002-03

Petroleum Products	Average (In '000 tons) 1970-71 to 1989-90	1990-91 to 2002-03	Per cent change	Growth rate (1990-91 to 2002-03)
Liquified Petroleum Gas	747.7	4795.2	541.3	2.60
Motor Gasoline	1863.3	5085.7	172.9	2.69
Naphtha	2397.9	6667.4	178.1	3.39
Kerosene	4800.8	10029.3	108.9	2.73
Aviation Turbine Fuel	1160.5	1990.5	71.5	2.52
High Speed Diesel oil	10635.8	31788.4	198.9	1.72
Light Diesel oil	1182.5	1440.5	21.8	5.91
Fuel oil	6851.9	11079.2	61.7	2.23
Lubricants	608.8	979.7	60.9	4.59
Bitumen	1079.1	2228.0	106.5	2.22
Petroleum Coke	177.7	701.6	294.8	4.64
Refinery Fuel	1739.4	4260.5	144.9	3.54
Others	604.8	2416.8	299.6	3.37
Total	34093.0	84226.4	147.0	2.31

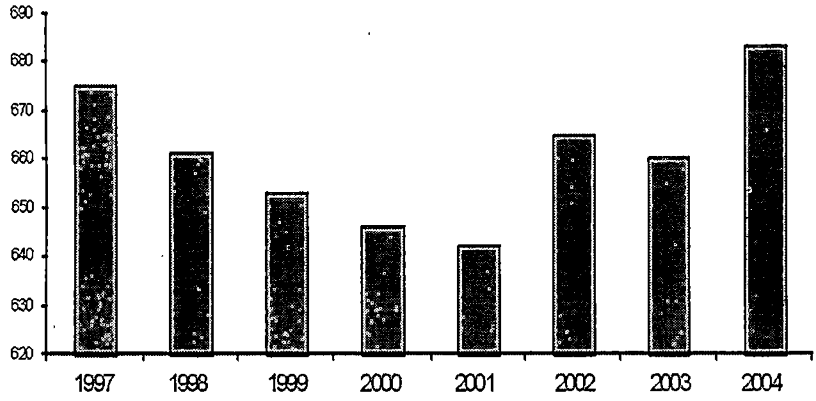
Source: Indian Petroleum and Natural Gas Statistics, 2002-03/Ministry of Petroleum and Natural Gas, Govt of India, New Delhi.

ever-increasing demand for oil in India. Presently, the net import of oil in India is about 78 million tons and costs INR 760 billion. Future oil consumption in India is also expected to grow rapidly, to 2.8 million bbl/d by 2010, from 2.2 million bbl/d in 2003.[3] India is attempting to limit its dependence on oil imports by expanding domestic exploration and production. To this end, the Indian Government is pursuing the New Exploration Licensing Policy (NELP), first announced in 1997, which permits entry to multinationals. India proceeded with the award of 25 oil exploration blocks in early January 2000. Reliance Industries, in partnership with Niko Resources of Canada became one of the major explorers of oil. Our crude oil production according to the Tenth Plan Working Group is estimated to be around 33-34 mmt per annum even though there will be an increase in gas production from 86 mmsemd (2002-03) to 103 mmsemd in 2006-07. That will certainly leave a huge gap in the demand and the home production to be met with imports. This can be seen from the EIA sourced data presented in the figure.

Projected Future

It is very clear that if ideally biofuels (B-15) are substituted at 15:85 ratios, then the country will save sufficiently on fuels. The present

Figure 5: India's Crude Oil Production (Thousand Barrels per Day)



import of crude oil and petroleum products cost the government about INR 764,240 million (2003-04). If biofuels are substituted, the country will save about INR 114,640 million worth of foreign exchange. That will be a quite a large saving but it cannot happen in one go. If light diesel oil, motor gasoline, fuel oil and lubricants are to be substituted gradually with 15 per cent of bio fuels then the production of biofuels has to be in the range 2.8 million tons. This will need about 10 million hectares of land under these crops. The estimated national potential of biofuels is estimated at 2 million tons at today's consumption levels and may grow up to 200 million tons in the next two decades (see Tables 4 and 5). If one gets the present production scenario and the availability of land, the targeted programme could be drafted. The main challenge, however, will be the distribution network. This has to be sorted out by routing biofuels use through the existing fuel vendors and possibly by connecting a market chain incorporating the current Petro products distribution network.

Table 4: Projected Growth of Use in Fuel Oil: Future Plans

Item	Annual Growth %		
	10th Plan	11th Plan	12th Plan
Motor Gasoline (MS)	7.3	5.0	5.0
Aviation Turbine Fuel (ATF)	3.2	3.2	3.2
High Speed Diesel (HSD)	5.6	5.0	4.5

Source: Panigrahi *et al.* (2004).

Table 5: Projected Fuel Requirements and Domestic Supply

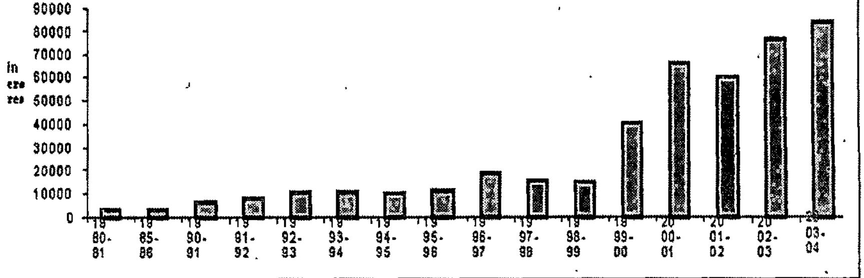
Item	Projection in thousand MT				Domestic supply %		
	2002-02	2006-07	2011-12	2016-17	10th Plan	11th Plan	12th Plan
MS	7070	10067	12848	16398	22.2	Lower than 10th	
ATF	2299	2691	3150	3687	22.2	Plan projection	
HSD	39815	52324	66905	83575	22.2	If foreign JV is ignored	
NG	81.33	179	313		47.9		

Source: Panigrahi *et al.* (2004).

International Agreements

One of the main issues that surfaces here for discussion is the role that biofuels will play in the context of international agreements. The Cartagena Protocol on Biosafety, which is commonly called as the Biosafety Protocol (BSP), is a multilateral environmental agreement that entered into force on 11 September 2003 after 50 countries ratified it. By 28 July 2004 there were 105 parties agreeing to the discipline of the Cartagena Protocol on Biosafety (BSP) (Canada signed the BSP but never ratified it and the US was never a party to it). The BSP explicitly allows countries to use the Precautionary Principle and allows countries to block products that have used unacceptable technology anywhere in its production. Therefore, the BSP will not be having any direct consequences for the biofuel sector. However, the part of the agreement that concerns on environmental quality may have to be considered here as having a clear bearing. Biofuels have implications for producers as well as the users of biofuels. For the producers it will be a question relating to finding markets and sustaining them, whereas the net importer may have to accept the quality and demand generated elsewhere. The Kyoto protocol, however, will have a clear bearing on the biofuel sector and will boost demand for biofuels. The Kyoto Protocol requires that

Figure 6: Net Import Value of Crude Oil in India



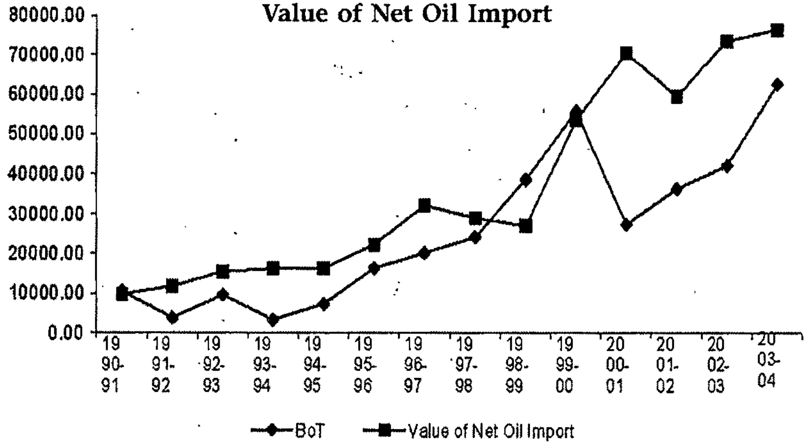
developed countries must reduce their greenhouse gas emissions by at least 5 per cent from the 1990 levels during the commitment period 2008-12. That would become obligatory and will certainly feature in the coming negotiations. In addition to these, the general discipline of trade and tariff will also operate in this context.

Trade and Foreign Exchange

Biofuels will enter the trade discipline not only as a commodity but as a category which will have significant economic and environmental implications. It is well known that oil prices and oil imports significantly influence the macro-economic parameters in developed as well as the developing world. The sensitivity of macro-economic parameters of developing countries to oil stocks is more critical. Among the macro economic aspects, Balance of Trade is quite an important determinant of countries trade performance. India had an adverse Trade Balance during the last three decades and a large share of this was contributed to by the oil sector. India has to depend largely on import of crude oil and such imports increased sharply during the nineties. The total import of the quantity of crude oil was 20,699 thousand m tons in 1990-91 which increased to 90,434 thousand tons in 2003-04 (see Figure 6). The foreign exchange spent on this trade was INR 61 billion in 1990-91 and that increased to INR 835 billion in 2003-04.

It becomes obvious that the oil sector is quite crucial for the trade balance (see Figure 7). The relationship between the aggregate trade

Figure 7: Trends in the Balance of Trade and Value of Net Oil Import



balance and value of net imports of oil sector is quite strong and the correlation works out to be 0.84 (significant at 1 per cent level of significance). In this context, the substitution of biofuels will influence trade balance though not substantially, at least by 15 per cent if one excludes the spill over effects.

The transport sector remains the most problematic sector as the search for an economical alternative to petroleum-based fuel has been unsuccessful so far. Hence petro-based fuels will continue to dominate the transport sector in the foreseeable future but their consumption can be minimized by implementation of the bio-fuels programme expeditiously.

Global Policy Environment and WTO

Biofuels have not been discussed in any global policy environment explicitly. However, there are sufficient leads that indicate the possibility of biofuels emerging on the scene sooner or later. In the global policy environment, bio-fuels are pertinent from three distinct perspectives. First, as discussed above it may be considered in the context of environmental agreements, due to its dependence on the biomass, reduction of harmful emissions and the impact on the forest use. It is feared that the utility of certain species may lead to their over exploitation but at the same time its positive effect on green-house gases will also be weighted. Second, the emission standards in the case of biofuels also features as an important point for discussion. It is stated in an official Report of the India's Planning Commission that the emission standards are globally accepted and that may boost the use of biofuels.[4] Third, since biofuels will be largely substituting the fossil fuels the trade angle enters into picture. This will bring in arguments about the support to the industry as well as the tariff discipline. That also provokes discussion of the policy in the WTO forum.

Biodiesel is now a tradable commodity with significant economic and environmental implications. It gets included in environmental goods and services. Bio-diesel is one component of biofuels and a chemical compound (an ester) that can be made from vegetable oils and animal fats. Bio-diesel can be used in its pure form or mixed with traditional fuels. Biofuels have a significant impact on the emission levels and these reduce the harmful gases to a large extent. These positive implications on environment brings biodiesel into the international debate. In the Kyoto Protocol, it is stated that the developed countries should reduce their emission levels. The CO_2; NO_2; and SO_2 emission standards are agreed upon and that would become obligatory (see Table 6). Many of these countries have already passed specific legislation establishing voluntary or mandatory replacement of fossil fuels by biofuels. Importing biofuels from other, mainly developing countries, could help them reach their targets. However, many biofuel exporting countries still face technical trade barriers. To prevent asymmetry between trade liberalization objectives and Kyoto Protocol reduction targets, new approaches and policy space are warranted in order to ensure that trade liberalization efforts and policies in implementing the Kyoto Protocol become truly and mutually supportive. Even though this belongs to environmental standards, it will certainly feature in the coming WTO negotiations. The main pollutants emitted in the combustion of fossil fuels are carbon, sulphur, and nitrogen oxides, along with suspended particles.

As a secondary pollutant, ozone is formed in the troposphere from interaction among hydrocarbons, nitrogen oxides and sunlight. These have significant impact on human health. Therefore, biofuels are justified on health and environmental grounds. As the developing countries use a lower amount of fossil fuels, the pollution levels are also quite low here; pressure may therefore be mounted, on the developed world.

The experience of many countries including Brazil show that biofuels could be produced at a low cost and the cost of production decreases over the years. Therefore, developing countries could take advantage of biofuels by producing for the purpose of trade. Notwithstanding all the advantages, biofuels are likely to face significant trade barriers from developed countries. First, the developed countries are almost fully dependent on indigenous producers and therefore,

Table 6: Emission Reduction due to use of Biofules

Emission	Reduction (%)
CO	67
HCHydrocarbons	30
PM Particulate matter	68
SOOT	50
PAH	85
CO_2	100
NO_2	2-6
S	8-100

Source: CETESB, 2004.

may support the sector substantially with domestic subsidies. Second, they could bring forth some restrictive regulations often based on quality and technology of production (non-tariff considerations), and third, the technology, as well as investment would favour fossil fuels, as the use rates of the fossil fuels would remain significant. That will provoke the oil exporting nations to take up the arguments especially on tariffs.

Biofuels have become a high priority issue in the US, the EU and in a number of other countries around the world, due to concerns about oil dependence, reduction in NO_2, S, and CO_2 emissions or restrictions on other octane enhancement additives and oxygenation. The National Biodiesel Board of the United States carried out studies on the introduction of biodiesel and a major part focuses on support to the farmers and trade implications. Soyabean and mustard are high on the US agenda for supporting the biodiesel sector. That fetches in the domestic support discipline under Aggregate Measure of Support. The Doha Declaration has a significant bearing on this issue. It states, "with a view to enhancing the mutual supportiveness of trade and environment, we agree to negotiations without pre-judging their outcome, on: (i) the relationship between existing WTO Rules and specific trade obligations set out in the Multilateral Environmental Agreements (MEA)".[5] (ii) It further states that the WTO negotiations without environmental goals shall not prejudice the WTO rights of any member that is not a party to the MEA.

Many countries have provided significant tax concessions to the users of biofuels. Germany and Italy levy no tax on biodiesel, whereas UK has a 20 per cent lower tax on biodiesel than on other fuels. Several states in US have lower taxes on biodiesel. In the EU, there is a preferential treatment for ethanol imports. Internal production is subsidized through tax reduction of as much as EUR 0.65 per gallon, Stlg 0.2 in UK, EUR 0.38 in France, and EUR 0.525 in Sweden (EIA). Soyabean based biodiesel is the main fuel substitute in US and Brazil and it is likely that soyabean growers of the US will benefit from large tax concessions and that may be used as one avenue to convert the actionable subsidies on soyabean sector in the US to non-actionable green box subsidies.

The biofuels sector interfaces with the WTO regime in five important ways. First, it involves *de-minimis* Market Access (WTO, Art XXXVII) featuring from the viewpoint of the Oil Exporting countries.

The international market for fossil fuels is well organized and any large-scale intervention in this situation is likely to be strongly resented. But probably that is a distant possibility due to the lower limits in the provision as well as the size of trade. Therefore, this issue may not come up for discussion in the immediate future, at least under this provision. The second issue arises from the Domestic Support angle, and here there is a possibility that trade in fuels may get restricted due to the possible generous support to the biofuels sector. The aggrieved countries may consider these as trade distorting support mechanisms and therefore these supports have to be classified into non-actionable groups or 'Green Box' with the help of the environmental sustainability argument. The developed countries may pick up this argument well before the developing countries could think about it. Nathanael in the Report on Growing Energy prepared recently, clearly indicates that the US should take advantage of the environmental angle to push the subsidies provided to farmers under non-actionable group.[6] Third, from the Sanitary and Phyto-Sanitary agreement point of view, acceptable standards of these biofuels have to be fixed before it gets into the trade discipline. These have to be internationally agreed standards. It is conceived by many that biofuels will be produced under the small-scale sector and if that happens then these standards will have to accommodate the conditions prevailing in the production system. The fourth issue crops up from the IPR regime of the WTO. Here the product patents have to be viewed before embarking on large-scale production of the product, if the production process as well as the product is going to be standardized. Last, the environmental angle and carbon trading arguments may enter in to the picture. The world community is discussing the Kyoto protocol and the emission discipline incorporated in it is the carbon trading argument. The protocol has set binding targets for reductions of emissions that each developed country has to commit and to endevour for such reductions. The protocol also provides institutions such as Clean Development Mechanism, Joint Implementation System and Emission Trading to promote activities for mitigating harmful impacts and deal with the impact of climatic change. These are likely to interface with the WTO discipline when the interested countries insist on the same. As such the Kyoto protocol has all that material needed for the trade regulation with environmental standards and that is the central point of the WTO discipline. Canada in 1999 suggested the setting up of a working group on biotechnology to find

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Annexure Table 1

Primary Energy Consumption by Regions: History and Projections

(Quadrillion Btu)

Region/Country	History				Projections			Average Annual Percent Change,
	1990	2000	2001	2010	2015	2020	2025	2001-2025
Developing Asia	52.5	80.5	85.0	110.6	129.7	150.5	173.4	3.0
India	7.8	12.7	12.8	16.4	19.5	23.2	27.1	3.2
Total Developing	89.3	133.8	139.2	175.5	202.5	232.4	265.9	2.7
Total World	348.4	398.9	403.9	470.8	517.3	567.8	622.9	1.8

Total Energy Consumption by Region and Fuel, Reference case, 1990-2025 (Quadrillion Btu)

Developing Asia

	16.1	30.2	30.7	42.0	49.2	57.4	65.7	3.2
Natural Gas	3.2	6.9	7.9	10.1	12.3	15.1	18.7	3.6
Coal	29.1	37.1	39.4	48.2	55.1	62.8	71.9	2.5
Nuclear	0.9	1.7	1.8	3.1	4.2	4.9	5.1	4.4
Other	3.2	4.5	5.1	7.2	8.9	10.3	11.9	3.6
Total	52.5	80.5	85.0	110.6	129.7	150.5	173.4	3.0

Annexure Table 1 continued

Annexure Table 1 continued

Region/Country	**History**			**Projections**				**Average Annual Percent Change,**
	1990	**2000**	**2001**	**2010**	**2015**	**2020**	**2025**	**2001-2025**
Total Developing Countries								
Oil	35.9	56.9	57.6	75.2	86.3	99.3	112.6	2.8
Natural Gas	10.8	20.4	22.4	26.8	31.7	37.6	45.5	3.0
Coal	33.5	42.8	45.1	54.7	62.3	70.7	80.4	2.4
Nuclear	1.1	2.0	2.2	3.5	4.7	5.4	5.7	4.1
Other	8.0	11.6	11.8	15.2	17.5	19.5	21.7	2.5
Total	89.3	133.8	139.2	175.5	202.5	232.4	265.9	2.7
Total World								
Oil	135.1	155.9	156.5	185.4	204.0	223.8	245.3	1.9
Natural Gas	75.0	91.4	93.1	108.5	122.0	138.8	156.5	2.2
Coal	91.6	93.6	95.9	108.0	116.6	126.8	140.2	1.6
Nuclear	20.3	25.5	26.4	29.8	31.4	31.8	30.4	0.6
Other	26.4	32.8.	32.2	39.0	43.2	46.6	50.4	1.9
Total	348.4	398.9	403.9	470.8	517.3	567.8	622.9	1.8

Sources: History: Energy Information Administration (EIA), International Energy Annual 2001,DOE/EIA-0219(2001) Washington, DC, February 2003),web site www.eia.doe.gov/iea/. Projections: EIA, Annual Energy Outlook 2004,DOE/EIA-0383(2004) (Washington, DC, January 2004),Table A1;and System for the Analysis of Global Energy Markets (2004).

Annexure Table 2: Oil Consumption by Regions: History and Projections

(Million Barrels per Day)

Region/Country	History			Projections				Average annual Percent Change, 2001-2025
	1990	2000	2001	2010	2015	2020	2025	
Developing Asia	7.6	14.5	14.8	20.2	23.7	27.6	31.6	3.2
India	1.2	2.1	2.1	2.8	3.5	4.4	5.3	3.9
Total Developing	17.3	27.6	27.9	36.4	41.8	48.1	54.5	2.8
Total World	66.1	76.9	77.1	91.4	100.5	110.3	120.9	1.9
Natural Gas Consumption by Region, Reference Case,1990-2025 (Trillion Cubic Feet)								
Developing Countries								
Developing Asia	3.0	6.6	7.5	9.5	11.6	14.1	17.4	3.5
India	0.4	0.8	0.8	1.2	1.6	2.0	2.5	4.8
Total Developing	10.1	19.3	21.2	25.2	29.8	35.3	42.6	2.9
Total World	73.4	88.7	90.3	105.1	118.1	134.2	151.1	2.2
Coal Consumption by Region, Reference Case,1990-2025 (Million Short Tons)								
Developing Asia	1,590	1,959	2,084	2,553	2,928	3,343	3,834	2.6
India	242	359	360	430	484	543	611	2.2
Total Developing	1,835	2.275	2,401	2,918	3,330	3,780	4,303	2.5
Total World	5,307	5,115	5,263	5,881	6,335	6,862	7,574	1.5
Nuclear Energy consumption by Region, Reference Case,1990-2025(Billion Kilowatt hours)								
Developing Asia	88	171	178	299	406	473	497	4.4
India	6	14	18	46	55	66	66	5.5
Total Developing	105	195	209	339	455	518	549	4.1
Total World	1,905	2,434	2,251	2,838	2,994	3,032	2,906	0.6

Sources: History: Energy Information Administration (EIA),International Energy Annual 2001,DOE/EIA-0219(2001) Washington, DC, February 2003),web site www.eia.doe.gov/iea/. Projections: EIA, Annual Energy Outlook 2004,DOE/EIA-0383(2004) (Washington, DC, January 2004),Table A1;and System for the Analysis of Global Energy Markets (2004).

India-Philippines to cooperate in agricultural biotechnology

India has handed over the foundation seeds of improved varieties of peanut and sweet sorghum to the Philippines for better production and processing of the output. The International Crop Research Institute for Semi-Arid Tropics (ICRISAT) in India developed these varieties. One of the peanut varieties, ICGV 86564, has been commercialized in some parts of India and has been of large benefit for farmers. During the recent visit of the President of India to the International Rice Research Institute (IRRI), Philippines, an MoU between the two countries on agricultural biotechnology cooperation was signed.

The two countries have also launched joint work in rice production and processing in which the Philippines a based IRRI has comparative advantage. India would be interested in the development of new, nutritionally enhanced rice varieties. New impetus is being planned for the ongoing IRRI-India collaborative effort programme to develop drought-tolerant varieties that are expected to have a substantial impact on increasing productivity and reducing poverty in Eastern India. India has around 176 million hectares of land currently available for cultivation, which by 2020, would reduce to 100 million hectares. The other areas of cooperation include, dry land farming, multiple cropping, bio-organic farming, agriculture machinery horticulture, cotton growing technology, sugar technology, integrated pest management and plantation crops. There was a proposal to enhance India's support for IRRI's research – which currently averages about US$150,000 a year.

Decline in new agri-biotech product applications in US

The approved biotech crop for commercialization in the US has decreased significantly in product commercialization from 1995 to 2000. And it decreased by two thirds in the number of applications filed since the year 2000.The trend of decline in this technology was due to the lack of an efficient review process and adoption, stream lined public investment, risk assessment and safety studies, evaluation of farmer's need and the improvement of public acceptance for this technology. These issues were revealed in a study report by Centre for Science in Public Interest (CSPI), a Washington based non-profit education and advocacy organization that focuses on food safety and nutritional issues,

Biofuels could supply 30 per cent of global energy demand

The scientist from Georgia Institute of Technology, published a paper on 'The path forward for Biofuels and Biomaterials', in the *Science Journal*, whereby they recommended a multidisciplinary integration of perspectives by combining the approaches of biologists, agronomist, engineers, energy experts and policy specialists to achieve the transition from non-renewable carbon resources to renewable resource energy. Energy demand was projected to almost grow 50 per cent by 2025 with the increase in demand from developing countries. The developing countries economic growth could be mapped with the increase in demand for biofuels. Dr. Arthur Ragaukas and colleagues of the Institute highlighted the future energy challenges to convert biofuels into practical cost efficient alternatives to petroleum products. In their report, several countries plan to increase of biofuels for transport. A country like the US has plans to replace 30 per cent of liquid petroleum with biomass derived products by 2025; India has a targets to increase 5 to 20 per cent by 2012; European Union target to extract 6 per cent of fuel from biomass while Brazil has been producing highest amount of around 30 per cent of transport fuel derived from biomass. They analyzed the range of material used in biofuel production to include low cost agriculture wastage products, fast growing trees and perennial energy crops such as switch grass. The ground challenge for biomass production is to develop crops with physical and chemical traits to increase the biomass yields.

Greater Mekong sub-region countries promote agriculture ties

The regional programme on rural agriculture was initiated by the Greater Mekong Sub-Region (GMS) member countries at Thua, Thien-Hue, Vietnam. The strategic framework of the programme included development in agriculture and cooperation in trade and investment, scientific and applied technology research and use of natural resources and environmental protection. The Asian Development Bank (ADB) has been funding this programme since 2003 for the GMS Member countries like Vietnam, Laos, Cambodia, Thailand and Yunnan Province of China.

ICRISAT and CII partnership for agriculture rural development

The International Crop Research Institute for Semi-Arid Tropics (ICRISAT) and Confederation of Indian Industry (CII) are working together on improvement of natural resource management for sustainable agriculture. This initiative was aimed to strengthen partnership with the private sector through 'the Agri Science Park' Programme. The collaborative and strategic alliances will help private sector organizations to mobilize cutting edge S&T cooperation for the poor people in semi arid tropics of Asia and Sub-Saharan Africa.

Co-existence of GM and non-GM crops

The European Union's Joint Research Centre has recently published case studies to identify how farmers can reduce the unintended and unavoidable presence of GM material in non-GM harvests. This collaborative research was taken up by the follwing institutes: Francis Institut National de la Recherche Agronomique (INRA); Germany's University of Applied Sciences of Weihenstephan; European Commission's Institute for Prospective Technological Studies (IPTS) the Joint Research Centre (JRC) came out with these issues of the coexistence of GM and non-GM crops in EU's agriculture system.

In the report, they identified the agronomic performance necessary for the coexistence in the introtoduction of biotech crops. It was also based on the efficacy and feasibility of coexistence measures and the need for long-term effects of implementation of GM crops. The case studies covered crop and seed production of maize, sugar beet and cotton and their threshold values. The studies examines the issue on a regional scale through simulation using data on EU agriculture landscapes, weather conditions and agricultural practices. The main conclusion from the case studies was that crop production at the 0.9 per cent threshold set by EU is feasible with few or no changes in agriculture practices, if adventitious GM presence in seeds does not exceed 0.5 per cent. The production seed of up to 0.5 per cent GM seed would be possible with little or no change in the current seed production practices.

CSIRO developed new wheat for improved digestion

The Australian Commonwealth Scientific and Research Organization (CSIRO) developed a new variety of experimental wheat with altered starch composition that could help in the improvement of public health. Dr. Mathew Morel, a leading scientist, works on the RNA interference (RNAi) through the gene silencing method. According to Dr. Morel, "In this technique, a gene construct carrying a fragment of a target gene cloned in both orientations is transformed into a host plant. When the double stranded RNA expressed, the homologous mRNA degradation takes place. And this process helps the plant to defense against the viral attack. Through the RNAi to reduce the expression levels of two starch branching enzyme to get 70 per cent amylose, instead of the 25 per cent present in standard wheat through a molecular marker, which will help in animal growth rate".

Biosafety violation in GM food crop trial in India

The Centre for Sustainable Agriculture (CSA), a Hyderabad-based organization, presented an evidence of biosafety violation in GM food crop trials of brinjal and rice varieties in the Andhra Pradesh State of India. In their report, the CSA complained of gross violations of the Environmental Protection Act (EPA Act) and absence of liability and a monitoring mechanism of Genetic Engineering Approval Committee (GEAC) of the Ministry of Environment and Forest (MOEF), Government of India. However, the CSA also uncovered a violation of biosafety in the Bt bhindi field trial being conducted by Mahyco at Guntur district of Hyderabad. The report was also presented to the Monitoring and Evaluation Committee (MEC) of GEAC for appropriate action. The GEAC also admitted that, it had no information on where trials are going on in the country. "India is yet to decide a coherent and publicly debated policy on whether GM food crops are needed and what are the risk associated with it," said the Executive Director of CSA.

Germany passed third GM amendment law

The German Parliament passed the new law, which regulates application, proceeding, processing deadlines and monitoring rules of GMOs. Parliament also finally accepted the EU-GM guideline with elaborate regulation concerning GM crops and unintentional release of transgenic organisms. This Third Amendment Law focused on existing law and issues concerning fixing of liability due to transboundary movement of GMOs. Before amendment of this law, German government commercialized GM maize of MON810 varieties in 1500 hectares of land. But, there was an immense pressure from farmer communities for the liability and redress issues in GMOs.

South-South research partnership on desertification

The countries of Central and West Asia and North Africa (CWANA)-plus partnership have promoted scientific collaboration between the Middle East, North Africa and Central Asia to boost research on desertification. This partnership was initiated by United Nation University (UNU) and International Centre for Agriculture Research (ICRI), Syria to train scientists and for sharing the resources and expertise. The degradation of dry land and livelihoods is a major cause of concern for these countries. The partnership was aimed to conduct research and promote practical ways for tackling desertification and the protection of livelihoods.

According to the China State Forestry Department, nearly one-fifth of China's total area is covered with deserts that could have an impact on agriculture and human settlement in future. The government has announced a 'desert control scheme' with private sector involvement for a tree planting project. "The most important task is to work out robust research-based plans to meet the specific demands of each element of the desert control battle," said Wang Tao, Director of the Cold and Arid Regions Environmental and Engineering Research Institute in Lanzhou.

AIDS R&D centre opens in Cameroon

The international partnership led by UNESCO opened a HIV research centre in Yound'e, Cameroon. The centre would run clinical trial of vaccines to protect babies from getting HIV from their mothers while breastfeeding. According to World Health Organization report, breastfeeding could account for up to half of HIV infections in infants and young children, where the practice is prolonged. The centre also worked on HIV/AIDS diagnosis, research and training for the researcher in that region with the collaboration of the Italian Health Ministry, European Union, UNESCO and the Government of Cameroon.

Vietnam approves major fund for GM crop research

The Government of Vietnam approved $63 million over the next 15 years on agriculture biotechnology. The investment will support applied research, technology development and human resources. The aim of the programme was to create more varieties of plants, microorganisms and agricultural products with higher qualities and improving GM varieties.

The Ministry of Agriculture and Rural Development (MARD) has planned to carry out 12 scientific research and pilot production projects through the recently approved "Key Programme on Development and Application of Biotechnology in Agriculture and Rural Development Through 2020". Under the programme, the ministry will build capacity by: training scientists; technical infrastructure; international cooperation; effective implementation of advanced biotechnologies; and the promotion of R&D projects. The programme aims to encourage technology transfer, form a favourable market, and promote the formation and development of the biotech industry in agriculture. The government has planned to increase the proportion of biotech crops to 70 per cent of the country's total crop area by 2020.

Bangladesh to formulate National Biotechnology Policy

The Government of Bangladesh is planning to adopt a National Biotechnology Policy (NBP) and National Biosafety Framework (NBF) by the end of the year, which aims the application of genetic modification in crops, livestock, risk free environment and human health. The National Executive Committee (NECB) will be responsible for the implementation of the national policy to ensure speedy and better development of technology. It also set a plan of 20 years to keep pace with R&D in biotechnology and genetic engineering. Under the draft policy, government plans to set up a biotech incubator, venture capital fund, and bank credit for biotech companies. In the policy, the intellectual property right, biosafety, biosurvellience and bioethics issues are included to emphasize on knowledge, innovation and indigenous practices. Presently, Bangladesh has four varieties of GM drought resistant and saline tolerant rice, late blight of potato, fruit and shoots borer resistant chickpea. The Bangladesh Rice Research Institute (BRRI) and Bangladesh Agriculture Research Institute (BARI) are testing the GM rice and eggplant in a green house environment before releasing for commercialization.

Bangladesh was signatory to Cartagena Biosafety Protocol (CBP) but there was lack of guidelines to adopt GM crops. The NBF will work with the collaboration of Global Environment Facility (GEF). The Agriculture Biotechnology Support project II (ABSP II) funded by United States Agency for International Development (USAID) and Cornell University, USA has been supporting its biotechnology research and management in public and private partnership among institutions to develop GM crops. The project aims to boost food security, economic growth, nutrition and environmental quality in Asian and East and West African countries.

United States to decode soybean gene to increase biodiesel production

The United States Department of Energy (DoE) and Department of Agriculture (DoA) has collaborated to decode the DNA of soyabean for the production of biodiesel fuel through the genomic sequence. "The agreement of the joint research programme will support the high quality of genomic research and integration of projects to meet the country's challenge in agriculture and energy. The coordination of genome sequencing is run by Joint Genome Institute's Community Programme," said Dr. Ari Patronos, Associate Director of US Science for Biological and Environmental Research with the support DoE.

According to DoE report, *Glycine max* (soyabean) is one of the valuable legume crops and is also a source of biodiesel with environmental friendly energy. In 2004, over 3.1 billion bushels of soyabean were grown in 75 million acres with an estimated annual value of that income exceeded $17 billion. The Joint Genome Institute of California played a key role in the transnational genomic, which is applied for DNA sequencing for the development of new avenue of clean energy generation and crop improvement.

Central Committee for food standards recommends labelling in GM foods in India

An expert committee on GM food and ingredients constituted by the Indian Council of Medical Research (ICMR) has made recommendation to the Central Committee for Food Standards (CCFS) for mandatory labelling GM food products. The CCFS, which is a statutory body under Prevention of Food Adulteration Act 1954, Government of India, recommended the mandatory labelling of all GM food products.

India is a large importer of soyabean oil (believed to be crushed out of GM soyabean) and it is estimated that 20 lakh tons of Soya oil are imported by India in 2005. Since 2002, India has removed its quantitative restriction on imports and there has been a gradual reduction of import tariff with a large influx of food and ingredients from abroad. There is also commercialization of Bt cotton, where the country produces GM cottonseed oil and cottonseed cake/extraction (animal feed). But neither cotton nor the derivative products are marketed as a transgenic variety. For neither imported food products nor for domestic produce does labelling take pace.

United States and Brazil agreement on GM labelling

The United States accepted the Brazilian proposal on international labelling on GM foods. In the US, Alaska is one of the states to pass labelling for genetically engineered foods. This legislation may help the US Federal government to introduce mandatory labelling. Both the countries agreed to host headquarters of the Committee on Additives and Contaminants, which transferred to Brazil, because there was no Codex Alimentarius committee in developing countries. "It will be helpful for Brazil, as a developing country to coordinate the committee its importance in determining pesticide use limits, which have a major impact on world food trade," said a Federal Agricultural Inspector in the Ministry of Agriculture of Brazil.

Since 2003, Brazil has joined the Cartagena Protocol as a signatory country in favour of a label stating: 'May Contain Modified Live Organisms.' The majorities are opposed to a label stating 'Contains Modified Live Organisms,' because that would require the adoption of expensive crop detection and tracking procedures. Brazil has a committee to look after the segregation of GMO from conventional grains and set up GMO labelling and testing procedures within four years. Until that time, "may contain GMOs" will be used on GMO exports. Although the US has not ratified the protocol, it has expressed concern over its effects on global trade in agricultural commodities.

Japan and Brazil exchange on plant derived ethanol

Japan and Brazil would cooperate to promote plant-derived ethanol fuel with the help of private sector initiative. This agreement was set up in the first ministerial–level working group meeting in Tokyo. The cooperation between the two countries will look into the reduction of carbon dioxide emission of the green house effect. The ethanol-derived plant releases only carbon dioxide, which will be absorbed by the plants. This joint venture, Brazil-Jan Ethanol Company will serve the ethanol sales agency in Japan. The Petroleum Association of Japan (PAJ), an industry group of wholesalers, plans to introduce about 360,000 kl of plant-derived ethanol to enable Japan to achieve the goal of the Kyoto Protocol in the fiscal year 2010.

Brazil, the largest producer and exporter of ethanol in the world, produces around 15 million kilolitres of ethanol from sugar cane annually. The Japan Alcohol Trading Company and Petroleo Brasileiro S. A. (Petrobras), a Brazil oil company set up a joint venture to import alcohol made from sugarcane from Brazil to Japan. According to PAJ, the direct mix of plant derived fuel with gasoline may cause harm to the environmental standards of Japan, so they preferred to promote information sharing on the ethanol-derived plant.

(*Sources:* RIS based on *Crop Biotech,* 10 Feb. 2006; *Crop Biotech,* 10 Feb. 2006; *Crop Biotech,* Feb.2006; *Crop Biotech,* 03 March 2006; *Crop Biotech,* 03 March 2006; *Crop Biotech,* 03 March 2006; *Crop Biotech,* 03 March 2006; *GM Watch,* 06 March 2006; *Crop Biotech,* 10 Feb. 2006; *SciDev.net,* 02 March 2006; *SciDev.net,* 01 March 2006; *Crop Biotech,* 03 March 2006; *Crop Biotech,* 03 March 2006; *SciDev.net,* 02 March 2006; *Crop Biotech,* March, 2006; *Crop Biotech,* 18 Jan. 2006; *Business Line* 08 Dec. 2005; *Crop Biotech,* 10 March 2006; *Crop Biotech,* 10 Feb. 2006; *Crop Biotech,* 09 Feb 2006; *Crop Biotech,* Aug, 2005,*TMC net,* 10 April 2006).

Document

Biofuel Policies in Asia*

High price of oil boosting biofuel production in Asia

The high price in oil have heightened the oil, concerns in Asia and most of the Asian countries are still facing higher oil prices. The net oil imports, as a share of nominal GDP in Asia, was 1.1 per cent in 1995 and the figure rose up to 2.2 per cent in 2003.

Malaysia, the largest producer of palm oil is planning to reduce diesel imports by 500, 000 tons a year and will produce a biodiesel using a mix of palm oil and diesel. The palm oil diesel is set to be a viable alternative for petroleum diesel in Malaysia. The national biofuel policy of Malaysia has been drafted to encourage the production and domestic consumption of palm oil, which is environment-friendly and an alternative source of energy. The Malaysian Palm Oil Board (MPOB) commences the construction of three-biodiesel plants with a combined annual capacity of 60,000 tons and plan to use 5 per cent processed palm oil blended with 95 per cent petroleum diesel within the country and explore exports of the same to European countries.

China launched its bioethanol programme in 2000 with an objective to end fuel shortage, air pollution and enable development of the rural economy. More than 80 per cent of ethanol is made from grains including corn, cassava, rice, etc. It produces ethanol in the ratio of 10 per cent from sugar, 6 per cent from paper pulp waste residue, and the rest from the ethylene by synthetic process. Subsequently, China, the third-largest ethanol producer in the world, produces around 3 billion litres of ethanol annually. Presently, it imports over 30 per cent of oil supplies and is consuming 5.46 million barrels a day (mbd); that is 7 per cent of the world demand.

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* Prepared by Bijaya Kumar Sahu, Researcher, RIS.

Indonesia, the second largest producer of palm oil, exported two million tons in 2005 with an 11 per cent increase from 2004. The Indonesian Palm Oil Producer Association is playing a vital role in increasing palm oil production and improving the production quality. In Thailand, the Government plans to replace regular gasoline with a mix that includes 10 per cent ethanol in 2007.

The Asia Pacific operations of the UK-based DI Oils, based in Manila, are providing biodiesel to the Philippines, Japan, China, Korea, Taiwan and Australia. The company is producing biodiesel from the *Jatropa* plant and has planted 267 000 hectares in Ghana, Madagascar, South Africa, India and the Philippines. India also announced a national biodiesel purchase policy for biodiesel producers to get a support price of Rs 25 per litre for *Jatropa* oil, and intends to bring one million hactares of land under *Jatropa* cultivation to supply blended diesel within few years.

Biofuels gathering momentum in India

India is looking at biofuels as a viable alternative to petroleum diesel and exploring the main commodity sources for biodiesel which can be non-edible oils obtained from plant species such as *Jatropha curcas* (Ratanjyot), *Pongamia pinnata* (Karanj), *Calophyllum inophyllum* (Nagchampa), *Hevcca brasiliensis* (Rubber), etc. The relentless rise in oil prices has led to a boost in the use biofuels like ethanol as also to biodiesel production as new sources of energy. Biofuels could help fight global warming by producing fewer green house gases, such as carbon dioxide. They also cut emissions of other toxins, like nitrogen dioxide, which contribute to the rising rates of respiratory diseases in many cities.

The Ministry of Petroleum, Government of India, is playing an important role through the Petroleum Conservation Research Association (PCRA), by launching the National Mission on biodiesel and replicating the existing synergy between the Ministry of Agriculture, Rural Development and Non-Conventional energy of the Government of India. This Mission was launched to give a boost to biofuel production, which can reduce the country's dependence on imported diesel by as much as 20 per cent. Government invested Rs 90 million on the biofuel project in 2004-05. The allocation for the current year has been scaled up to Rs 450 million and Government has announced a purchase policy for ethanol and biodiesel fuels on a per litre basis, that is, Rs 18.75 for ethanol and Rs 25 for biodiesel, for a stipulated quality.

India has also formulated an action plan for the setting up of the Bio-Fuel Development Authority (BDA) and identified Government-owned waste or fallow land as well as constituting task forces in various states to take the initiative for planting *Jatropa*. The action plan envisages encouraging the private sector to invest in contract farming, the setting up of an oil-expeller and transesterification plant for bio-diesel production. This programme was aimed to create awareness to make the people self-sufficient in energy and to generate employment in the rural areas. The issue of biodiesel has assumed significance with the rise in prices of crude oil in the international market. According to a World Bank report, India, consumed about 110 million tons of petroleum products and about 40.6 million tons of diesel in a year. The domestic production is only 30 per cent of the country's demand and the remaining 70 per cent of the demand is met through imports.

The Indian Oil Corporation (IOC) and Hindustan Petroleum Corporation Limited (HPCL) of the Government of India are experimenting with various mixes of bio-diesel with diesel in consultation with while sharing the results of the experimentation with the automobile industry. The IOC has also signed a memorandum of understanding with the Indian Railways for plantation of *Jatropha* on railway land. The National Bank for Agriculture and Rural Development (NABARD) has also initiated a pilot project on biofuel in the *Jatropa* and *Jojoba* variety. At the same time, the National Oilseeds and Vegetable Oils Development Board, under the Ministry of Agriculture is providing a back-ended subsidy of 30 per cent, for the promotion of tree-borne oilseeds like *Jatropa and Jojoba*. The Government has estimated the cost of production at Rs 20 per litre if the cost of seeds is taken at Rs 5 per kg.

In India, Gujarat is the first state to run commercial buses using biodiesel fuel. There remain major barriers to the wide spread adoption of biodiesel, which need availability of feedstock. So far, Indian corporates like the Tata Consultancy Services (TCS), Reliance Industries Limited (RIL) and Godrej Agrovet Limited have started a biodiesel agreement with some of the foreign firms. The public and private sector companies such as Indian Oil Corporation (IOC), Indian Farmer Fertilizer Cooperative Limited (IFFCO), Oil and Natural Gas Corporation Limited (ONGC) and Emami have started biodiesel projects in the collaboration with state governments for contract farming of this plant. The private sector has shown great interest in *Jatropha* cultivation. Besides bio-fuel, another bi-product is glycerol used for extracting glycerine. Also the residual cake could be used for biomass power generation. There is also a joint venture between Tinna Oils and Chemical Company of the United States with Indian firms. In the southern part of the country, Bannari Amman group, a biodisel production company, has installed a bio-diesel plant with a daily crushing capacity of 3,000 litres. The company is planning to enhance the crushing capacity ten-fold, by expanding the area under *Jatropha* in a phased manner and has cultivated *Jatropha* in 2,000 acres of land. Nandan Biomatrix, an Indian based company, has an agreement with the UK based Synergy Foundation for the plantation of *Jatropa* in one million acres of land for seven years. The Government has also planned to cultivate these varieties in four lakh hectares along with a seed fund of Rs 15000 million. India is producing a large amount of sugar and the output of molasses from the sugar gives more profit for the making of ethanol. The cultivators, especially in the case of biodiesel, need initial support as the oilseed plants take more than three years to get a full harvestable yield. Apart from producing the much needed biofuel this programme will also help in creating enormous employment opportunity through rural employment guarantee schemes.

Bio Web*

Biofuels are gaining importance worldwide as countries are seeking to cut emissions to meet the UN Kyoto Protocol, since burning the environmentally–friendly fuel is considered to be carbon dioxide neutral and does not require emissions. Biofuels are also seen as being more competitive due to a surge in global oil prices and their use could help fight global warming by producing fewer green gases and cut emissions of toxins. We provide here a list of select websites of such organizations pursuing research and development on biofuels.

— Editor

http://www.biofuels.doe.gov/

The United States, Department of Energy's, Office of the Biomass Program (OBP) is working in the area of biomass fuels, chemicals, materials, and power. The OBP has as its main objectives the reduction of dependence on foreign oil by developing biomass based liquid fuels and to foster the domestic biomass industry. It works in collaboration with the United States Office of Industrial Technologies (OIT) for research and development on advanced technologies and has produced biofuels, biopower, and high-value bioproducts. This Biomass Programme is a combination of the biofuels, biopower, and the biomass-related elements.

http://www.biodiesel.at/

The Vienna-based Austrian Biofuel Research Institute, works on liquid biofuels and biodiesel projects. It also conducts biofuel research feasibility and overseas development of fuel standards quality management, research and development, and dissemination. This institute helps the government in an evaluation of the biofuels industry, training in laboratory testing procedures, and on how to convert fleets to run on biofuels. This institute supports the formulation of national biofuel standards that meet the intended customers' quality requirements to promote market place presence.

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* Prepared and compiled by Bijaya Kumar Sahu, Researcher, RIS.

http://www.bioenergyinternational.com/

The Bioenergy International, Stockholm-based websites brings out publications on bioenergy international issues and also publishes research papers and distributes these to subscribers, members of Bioenergy Associations all over the world. These are also circulated to exhibitions and conferences. Also published, here are, "Bioenergi" and environmental magazines. It can also be reached through the www.novator.se the home web link of the bioenenergy- and environmental issues.

http://www.teriin.org/

The Energy Research Institute (TERI), a New Delhi, India-based research organization works on projects and publishes information on biofuels, utilization of biomass, agriculture residues, and many industrial wastes as fuels. The Institute is involved in the development of biomass gasifiers for thermal applications in small- and medium-scale industries. It plays an enhanced role in the biofuels resource and consumption surveys pre-feasibility studies, technology assessment, preparation of investment proposals and techno-economic feasibility studies.

http://www.ebio.org/

The European Bioethanol Fuel Association (eBIO), an International bioethnol producing companies association based in Brussel, produces ethanol from bio-origins through fermentation, distillation and dehydration processes. Members of this Association produces biofuel technology and oil extraction through distillation process. The eBIO is biofuel policymaking body of the biofuel producing member companies.

http://www.ethanolindia.net/

The Government of India, biodiesel pilot project was launched to give a boost to the agriculture sector and to reduce environmental pollution. This has been approved for the supply of ethanol-doped-petrol in the country. India had launched three pilot projects; two in Maharashtra and one in Uttar Pradesh in 2001 and these pilot projects have been supplying 5 per cent ethanol-doped-petrol. Ethanol India is also doing research and development in the establishment of ethanol up to 5 per cent with petrol and the usage of ethanol-doped-petrol in vehicles.

http://www.praj.net/

Praj Industries Limited, Pune, an India-based biodiesel company produces biofuel technology and oil extraction through molecular sieve dehydration plants for fuel-ethanol production, fermentation, wastewater utilization and heat-transfer systems. It produces fuel ethanol or anhydrous alcohol which is produced by dehydration of rectified spirit or extra neutral alcohol. Ethanol is used as part of the fuel, by blending with petrol, for a motor vehicle is called fuel-ethanol.

http://www.biodieseltechnologiesindia.com/

Biodieseltechnologies, Kolkatta, is an India-based consortium engaged in the study, improvement and research and development in *Jatropha*, and other species for the development of indigenous biodiesel. This organization is working on *Jatropha* cultivation, and oil extraction also designs process machineries for supplying custom built biodiesel reactor according to the requirement for the operators.

http://www.pcra-biofuels.org/

The Petroleum Conservation Research Association (PCRA), an autonomous body of the Ministry of Petroleum, Government of India has been promoting research and development in bio-fuels by sponsoring related projects to reputed R&D institutes of India. The National Informatics Centre on bio-fuels is a part of PCRA, which provides all the necessary information related to bio-fuels (biodiesel, biogas, etc.) by all manner of consumers as well as other agencies working in this field. It makes people aware of biofuels and helps them to get benefits from it.

http://www.d1plc.com/

D1 Oil plc, a UK-based low cost produceer of biodiesel, produces global, sustainable green transport fuel. It produces high value vegetable feedstock oils and high quality biodiesel.The company also has a global platform of planting and refining operations and production of fuel.D1 Oils plc is planting *Jatropha* in India through the joint venture company, D1 Mohan Bio Oils Limited in the north eastern part of the country and has also signed agreements for the supply of crude *Jatropha* oil up to 2015.

http://www.mpob.gov.my/

Malaysian Palm Oil Board (MPOB), a Kualalumpur, Malaysia-based research and development institution provides a highly diversified, value-added, globally competitive and sustainable oil palm industry. MPOB also produces biodiesel from palm oil and the production of palm biodiesel, which is very viable for Malaysian market.

http://www.carotech.net

Ccarotech Bhd. a Malaysia-based biodiesel exporting company exports crude palm oil and helps in provides development of biodiesel engine performance, emission testing. This company produces carobiodiesel, which is the brand of biodiesel obtained through molecular distillation technology for the production of this odourless and colourless biodiesel. It also produces the distilling varieties of methyl ester, carotene and tocotrienol from crude palm oil.

www.biofuelscorp.com

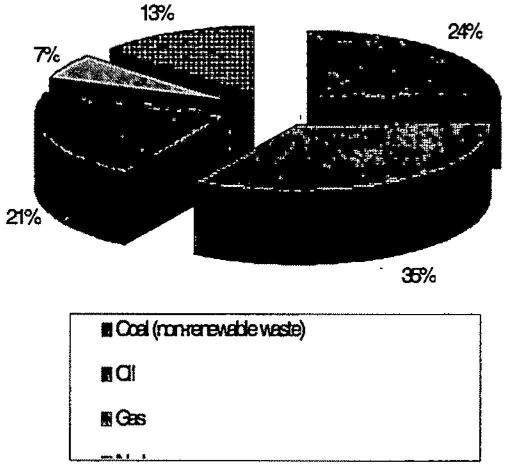
Biofuels Corporation, a UK-based biodiesel production company which is a leading international producer of biodiesel, glycerine and associated products, is providing for each a high quality product. The company has commenced commissioning of its 250,000 tonnes per annum biodiesel plant in Teesside, UK, with the production expected to commence begin soon.

Bio Stat*

Global production and supply scenario of biofuels

Biofuels are an eco-friendly and alternative fuels prepared from domestic renewable resources. The global renewable energy market has expanded over the years. However, statistics on this are often clubbed with the wider concept of combustible renewable waste (CRW). This covers solid biomass, biogas, liquid biofuel and municipal waste, apart from biofuel and biomass-based energy sources. According to International Energy Agency, IEA (2006), renewable energy occupied 13 per cent of the global primary energy supply. Out of this, 80 per cent of the total renewables come from CRW and 16.2 per cent come from hydro power plant-based sources. In the combustible renewable waste, 97 per cent is based on biomass (see Figures 1 and 2).

Figure1: World Total Primary Energy Supply in 2003 (fuel share)



Source: IEA Energy Statistics, 2006.

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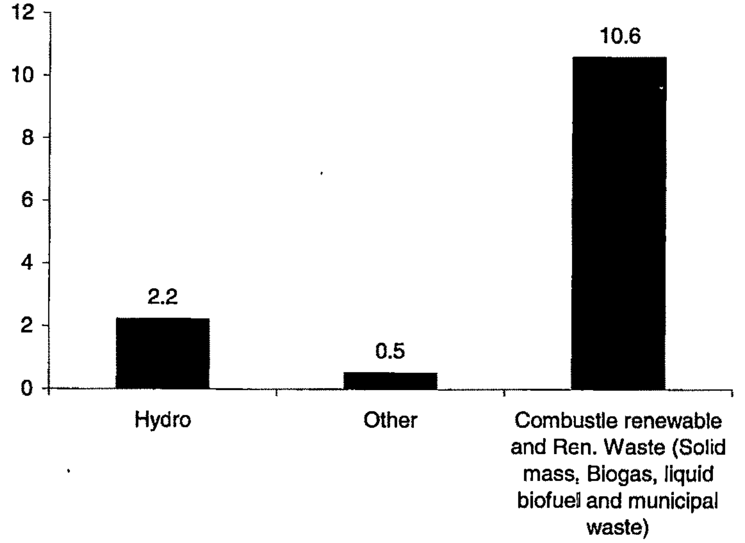
* Prepared by Bijaya Kumar Sahu, Researcher, RIS.

Figure 2: Renewable Energy Consumption in 2003 (fuel share)



Source: -IEA Energy Statistics, 2006

Among all biofuels, bioethanol has the highest demand. Its production in 2005 is estimated to be 46 million litres, of which 70 per cent is used as fuel (see Table 1). Brazil has a marginally higher share around 36.3 per cent in the global production followed by the United States (36 per cent). Rest of the players have a very low share in terms of production. In the European Union a greater policy emphasis is being attached to the development of biofuel, as a viable option. Spain, Sweden and Germany are among the top bioethanol producers in EU.

Table 1: Bioethanol Production in World

Country	2004 (Million in litres)	2005 (Million in litres)	Percentage in 2005
Brazil	14.6	16.7	36.3
United States	14.3	16.6	36
European Union	2.6	3.0	6.5
China	3.7	3.8	8.2
India	1.7	1.7	3.6
Africa	0.6	0.6	1.3
World	41.3	46.0	100

Source: Commission of the European Communities, 2006.

Table 2: Feedstock for worldwide production of biofuels

Source	Country	World wide production (2003-04) in MMT*
Palm kernel	Malaysia	3.50
Soybean	USA, France	31.83
Rape seed	EU, USA, Canada	12.57
Jatropha	India, Nicaragua	NA
Cottonseed	Greece	3.90
Used frying oils	Australia	NA
Sunflower	USA, Italy	9.42
Corn, Cassava, Rice	China	NA
Olive	Spain	2.81
Sugar cane	Brazil	14.8©
Linseed	Spain	NA

Note: - *million metric tonnes (MMT), NA: Not Available, © Brazil produced around 14.8 billion litres of sugarcane ethanol in 2005.
Sources: RIS database.

As is clear from Table 2, different countries are experimenting with different sources to produce biofuels. Brazil is heavily relying on sugar cane, while United States is delivering major share from soybean and sunflower. EU uses soybean and rapeseed and China is exploring options such as corn, cassava, and rice. India, Malaysia and Greece rely on *Jatropha*, palm kernel and cotton, respectively.

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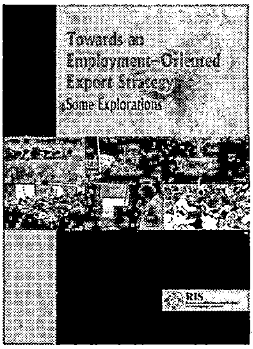
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RIS

India currently faces a major challenge of employment generation for millions of its unskilled and semi-skilled unemployed workers. The employment in the organized sector has shrunk in the recent years despite acceleration in GDP growth. India needs a manufacturing revolution to complement the booming services sector to meet the challenge of employment creation. Some countries like China, Malaysia, Thailand, among others have built export-oriented manufacturing industries and have created millions of job opportunities, while generating output and foreign exchange.

Export-oriented production has a huge potential for generating jobs. However, very little information has been available on the role that exports play in employment generation and policies that may help in that respect. This Report, prepared by RIS at the request of the Ministry of Commerce and Industry, explores into the role that exports can play in employment generation. It discusses the analytical issues in linking exports and employment generation and summarizes the international experiences on the subject. It makes the first exploratory attempt at estimating the role that export-oriented industry is playing in job creation and its potential. It outlines an employment-oriented export strategy that will not only strengthen India's place in international division of labour but can also improve the condition of its unemployed youth and generate new income and wealth. The government has taken cognizance of its findings and recommendations in the recent policy-making.

Towards an Employment-Oriented Export Strategy will be useful for policy makers, think-tanks, business professionals and development economists.

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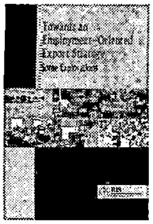

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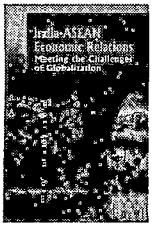

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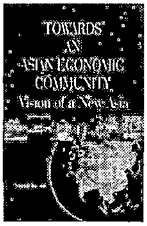

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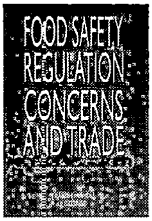

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Risk Assessment and Management of Genetically Modified Organisms under Australia's Gene Technology Act: Considerations for Regulatory Development

Nicholas A. Linacre*; Jose Falck-Zepeda*; John Komen*; and Donald MacLaren**

Abstract: Compared to both Canada and the United States, Australia has been slow to approve commercial planting of transgenic crops. Two probable reasons exist for the slow approval rate of transgenic crops in Australia. The first reason is community perceptions about the risks associated with transgenic technologies. The second is the regulatory framework currently employed to approve commercial releases. This paper examines some of the potential regulatory issues that may be affecting the review process and approval of transgenic technologies. First, we provide a brief introduction to the regulatory structure in Australia; second, we consider the impact of regional, national and state jurisdictions; third, we argue that the regulator needs to consider the use of benefits analysis in decision making; fourth, we argue for the use of probabilistic risk assessments in certain circumstances; and fifth, we look at potential problems inherent in majority voting in a committee and recommend alternatives.

Keywords: GMOs, Risk Assessment, Regulation, Australia

Introduction

Compared to the extent of approved GMO commercial planting in both Canada and the United States, with 4.4 and 42.8 million hectares, respectively of transgenic crops under cultivation,[1] Australia has been slow to approve commercial planting of transgenic crops. To date Australia has planted only 0.2 million hectares of transgenic crops,

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principally of GM insect-resistant cotton but also a small area of carnations modified for colour.[2] In 2003, approval was given for the release of a third crop, herbicide tolerant canola.[3] However, despite national regulatory approval, a number of Australian state governments imposed moratoriums on commercial plantings. Currently, there are several crop transgene combinations awaiting regulatory approval.

Two probable reasons exist for the slow approval rate of transgenic crops in Australia. The first reason is the Australian community perceptions about the risks associated with transgenic technologies[4] and the second is the regulatory framework currently employed to approve commercial releases. This paper examines some of the potential regulatory issues that may be affecting the approval of transgenic technologies. Two principal regulatory issues potentially affecting the adoption of transgenic crops are the failure of the regulatory system to include appropriate benefits assessments; and, ambiguity in the division of power between national and state governments. Two additional issues are discussed in this paper, relating to risk assessment approaches and voting systems. Neither of the two issues appears to be a major cause of regulatory paralysis, but may be important to address in order to encourage public confidence in decision-making.[5]

Regulatory Structure in Australia

The Australian Parliament passed the Gene Technology Act in the year 2000. The Act established a new single permanent national regulator, who reports to the national parliament – an individual who is responsible for licensing and releases of genetically modified organisms. To assist the single regulator, the Act also established a new regulatory agency, the Office of the Gene Technology Regulator (OGTR). The OGTR is the primary agency responsible for national regulation of genetically modified organisms. However, because of the multiple disciplines required for the analysis, a number of other agencies remain involved in the approval process, as shown in Table 1. Annex 1 provides the details of the institutions.

The Act is consistent with the precautionary principle that, where there are threats of serious or irreversible environmental damage, a lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation. The Act directs the Regulator to take into account of human health and safety and environmental risks in his deliberations on the environmental release of new genetically modified organisms (GMOs). The Act does

Box 1: Provision for Voting in GTA

Division 2, section 28 of the Gene Technology Regulations, 2001 specify the following decisions by majority voting.

(1) A decision of the Gene Technology Technical Advisory Committee is made by a majority of the members present, and voting for the decision, at a Committee meeting.

(2) The member presiding at a committee meeting has a deliberative vote and also has a casting vote in the event of an equality of votes by members present.

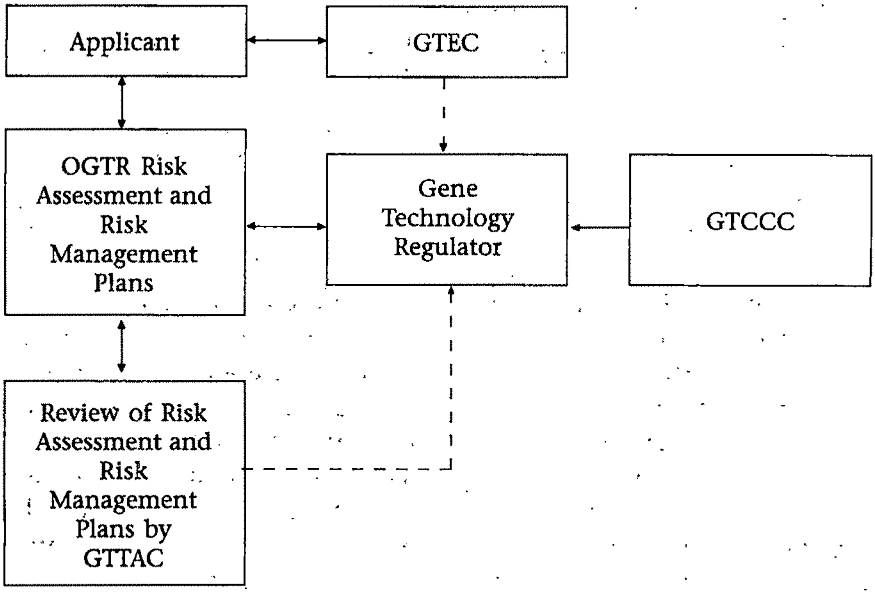
Source: GT (2001).

not direct the Regulator to consider the environmental or socio-economic benefits of such releases (Government of Australia 2000).

The Act also established a policy committee and three advisory committees that have different roles (see Fig. 1). The policy committee, the Gene Technology Ministerial Council, issues policy principles, policy guidelines and codes of practice that govern the activities of the Regulator. The committee has powers to appoint or dismiss the Regulator, and the chairpersons of the Gene Technology Technical Advisory Committee, the Gene Technology Community Consultative Committee, and the Gene Technology Ethics Committee. The Gene Technology Community Consultative Committee (GTCCC) advises the Regulator and the Ministerial Council on community views on issues surrounding the regulation of gene technology and allows for community input into the development of the policy guidelines and codes of practice. The Gene Technology Ethics Committee (GTEC) provides advice to the Regulator and the Ministerial Council on ethical issues relating to gene technology.

The Gene Technology Technical Advisory Committee (GTTAC) plays a central role in peer review of the risk assessment and management plans developed by staff in the OGTR. The Regulator must seek inputs from the GTTAC on the risk assessment and risk management plans developed by the OGTR (OGTR 2002b). A negative finding by this committee would condemn any license proposal. From this perspective, the committee, though advisory, is pivotal in the decision-making process because it is unlikely that the Regulator would ignore a safety recommendation by the committee. The committee is composed of 18 expert members drawn from a range of disciplines. Regulations to the Act specify the use of majority voting for decision-making by the GTTAC (see Box 1).

Fig. 1: Interrelationship between the Gene Technology Regulator, the agency and various committees (GTTAC, GTEC, and GTCCC)


Applicant
GTEC
OGTR Risk Assessment and Risk Management Plans
Gene Technology Regulator
GTCCC
Review of Risk Assessment and Risk Management Plans by GTTAC

Impact of Regional, National, State Jurisdictions

Existing regional structures are in place to develop coordinated standards for the approval of foods. The Food Standards Australia New Zealand (FSANZ) is a bi-national independent statutory authority that develops food standards for composition, labelling and contaminants, including microbiological limits, that apply to all foods produced or imported for sale in Australia and New Zealand. In Australia, FSANZ is involved in the approval process for transgenic crops destined for human consumption (see Table 1). Despite the success of the FSANZ regional approach, no coordinated approach exists for the approval of environmental releases of transgenic crops between Australia and New Zealand. A regional approach to the environmental approval of transgenic crops may be difficult to develop due to difference in ecological systems between Australia and New Zealand.

The issue is also complicated at the domestic level in Australia. In 2003, approval was given by the OGTR for the release of a third crop, namely, herbicide tolerant canola.[6] GM canola poses a contentious issue with some interest groups because of the possibility of gene flow.

Table 1. Responsible Agencies for Genetically Modified Organisms in Australia and the United States.

Subject	Responsible Agency	
	Australia	USA
Food and Food Additives	(OGTR), FSANZ, AQIS	FDA, FSIS
Pesticides	(OGTR), NRA, EA	EPA, APHIS
Biologics	(OGTR), TGA, EA	FDA
Animals and Plants	(OGTR), EA, FSANZ	APHIS, FSIS, FDA

Source: Compiled by Authors.

Oil seed rape (*Brassica napus*) comprises 45-50 per cent of Australia's canola crop. The pollen from *B. napus* is heavy and sticky but may become airborne due to its small size. The pollen is primarily dispersed by wind with the honeybee being an important dispersal vector over longer distances. The majority of pollen travels less than 10 metres. However, long distance dispersal events can occur due to wind (1.5 km) and insects (4 km). The proposed release was for canola modified to be tolerant to glufosate, replacing low yielding conventionally derived triazine tolerant canola. The GM variety was expected to provide environmental benefits, replacing triazine compounds – that remain persistent in both soils and water – with glufosate, which breaks down more rapidly.[7] However, despite national regulatory approval that GM canola is safe for commercial release, a number of Australian state governments imposed moratoriums on commercial plantings. In Australia, state governments are responsible for land management issues. This demarcation of responsibilities between the national and state level allows state governments to impose moratoria.

In Victoria, the state government commissioned a study to help it determine whether or not the moratorium should be extended beyond the initial one year.[8] Despite sound economic analysis, and a recommendation that the state government should allow commercial plantings for a limited period, in order to establish the magnitude of the risks involved, political considerations took precedence and the moratorium was extended for a further four years based on the perceived concerns of the community about GM crops.

Cost-Benefit Analysis

The risk assessment framework used by the OGTR does not explicitly allow any consideration of the human health or environmental benefits that might accrue from the release of a GM organism.[9] It is stated in the risk analysis framework that, "the risk assessment will be transparent, objective and scientifically based. It is purely based on *risk, not on a balance of risk and benefit"* (emphasis added).[10] It is also stated that: '[e]ither the risk will be too great to permit the dealing to proceed, or the risk will be manageable, or there will be no risk that requires management'.[11] The natural question to ask is: at what level is the risk too high? For example, in the risk assessment and management plans, words such as low, negligible, and manageable are used (e.g. OGTR 2002d, 2002e). However, if the *status quo* is presumed safe, then any technological change creates some risk no matter how small and a justification is required for undertaking the risk. This justification is missing from the GM crop risk assessments under the Australian system (e.g. OGTR 2002d, 2002e). More comprehensive analyses should also consider the *risks of not approving* novel GM products, which may imply the continued use of, for example, triazine.

Without explicit consideration of any benefits in the conduct of a risk assessment, it is difficult to understand how any decision, no matter how inconsequential the incremental increase in the risk, could be made in favour of the release of a GMO. In other words, the underlying philosophy of the Act is risk minimization rather than the more comprehensive philosophy of balancing the overall social costs and benefits of licensing a particular GM crop.[12]

To illustrate this deficiency in the current approach taken in the Act, suppose that a genetically modified virus that targets the reproductive system of foxes, makes them infertile. The fox is an introduced species in Australia that is thought to be responsible for the decline of many small, endangered, marsupial populations. The risk is that the virus could mutate and spread to the native dog (the dingo) and to dogs kept as domestic pets. On a purely risk basis such a proposal is unlikely to be approved because no recognized benefit is calculated against which to compare the cost. However, a decision to accept the risk to dingoes and domestic dogs can only be made sensibly in relation to the conservation benefits derived from a reduction in fox numbers.

Another deficiency in the current approach is that the Australian Gene Technology Regulator ignores the economic behavioural response of individuals towards the environmental management rules set by the regulator and excludes consideration of economic benefits and costs. Such a position ignores the important role economics plays in shaping the decisions individuals make. Behavioural analysis is essential because if an economic incentive exists for non-compliance, then the rules set by the regulator are unlikely to be followed unless adequately enforced. This is a well-documented problem in the United States, where concern about the emergence of insect resistance in the European corn borer, prompted the establishment of refugia (areas set aside for planting non-genetically modified crops). Such areas may or may not be effective in managing the emergence of insect resistance, much depends on the economic behavioral response of farmers to this added cost and the ability of the United States EPA to enforce the rules.[13]

The idea of explicit benefit calculations in risk management is not new. Kopp *et al.* (1997), Omenn *et al.* (1997), Farrow and Toman (1998), and Lutter (1999) all argue for the integration of benefit-cost analysis and risk assessment. The purpose of the benefit-cost analysis is to assist social decision-making, the objective being the efficient allocation of society's resources.[14] Some authors consider that risk assessment is a subset of benefit analysis.[15] In the simplest cases , the expected utility theory may be used as the method of integrating benefit-cost analysis and risk assessment.

However, cost-benefit analysis may be criticized on a number of grounds. Of particular importance is the utilitarian assumption germane to cost-benefit analysis: the aggregation of individual utilities should be maximized, trading one person's utility gains against another person's utility losses.[16] Cost-benefit analysis also suffers from a number of practical problems that limit its value for decision making. For example, cost-benefit analysis is also not 'value free' and the usefulness of the analysis depends on the quality, training, and objectivity of the analysts undertaking the valuation.[17] The valuation of benefits and the choice of discount rates can be problematic, especially when non-market quantities are involved.[18]

Despite these problems with the measurement of expected social benefits, we believe that the framework of social the cost benefit analysis is worth using because it provides a more balanced and comprehensive approach to the social-decision making, in this case, GMO regulation.

Probabilistic Risk Assessment

The regulator in Australia uses qualitative risk assessments based on expert judgments about risk. These expert judgments are supported by empirical studies (e.g. Rieger *et al.* 2002).[19] However, this approach has problems. Psychological research on human perceptions of risk suggests that experts have difficulty in making objective assessments of risk because they are prone to a variety of perceptual biases known as information processing shortcuts which include: anchoring, framing, and hindsight bias.[20] The alternative to qualitative risk assessment is the use of probabilistic risk assessments, based on mathematical models, in which the assumptions and dependencies are made explicit and in which the effects of these assumptions can be measured and the most important ones identified.

The OGTR in Australia views probabilistic risk assessments as having limited value owing to the lack of the direct ecological information which is needed to build such models in the context of risks to the environment.[21] At least in some situations of importance, sufficient data are probably available for the development of basic decision models. For example, Rieger *et al.* (2002) and Salisbury (2002) provide data on canola gene flow, which could be used as a basis for model building and sensitivity analysis. The position of the OGTR only serves to highlight the weakness of its approach in which only qualitative assessments are used, because it fails to make explicit the vagueness of the probabilities involved, a vagueness which can be recognized and built into quantitative models and modeling processes by which, through alternative values, probabilities can be assessed. The significance of these probabilities for risk, and the consequent decision, can then be assessed through simulations.

The decision to approve the release of herbicide tolerant canola provides an example of the potential application of probabilistic risk assessments. In this situation, the decision was based on a series of studies of gene flow, for example, see Rieger *et al.* (2002). However, a probabilistic risk assessment (mathematical) model, in which the assumptions and dependencies were explicit, may have augmented expert opinion by better informing decision makers about the risks of gene flow by providing a tool to explore the effects of spatial scale on gene flow.[22] Such models may also have provided the regulator with a defensible method for establishing isolation distances to limit gene flow.

Group Decision Making

The method enshrined in the regulations to the Act is that the GTTAC use majority voting to arrive at its recommendation to the Regulator to grant or to refuse a license. Now majority voting is only one possible way of aggregating the preferences of individuals in a group in order to arrive at the optimal choice for the group, and as will be shown below, it is not necessarily the best way. Before discussing the optimal choice for a group, it is necessary to outline elements of the theory of individual choice. The remaining material in this sub-section draws heavily from Allingham (2002).

In order to characterize an individual's choices over a closed set of a finite number of mutually exclusive choices, it is necessary to make certain assumptions. The concept of a preference relation is a useful way of imposing some basic structure on such choices. It involves being able to specify for any pair-wise choices amongst alternatives, such as A and B, that either A is at least as good as B ($A \geq B$) or B is at least as good as A ($B \geq A$). If $A \geq B$ and $B \geq A$, then the individual is indifferent between the two $(A \sim B)$. A second assumption is made which imposes a certain consistency on choices. If there were three objectives of choice, A, B and C, then if for the individual, $A \geq B$ and $B \geq C$, then $A \geq C$. With this second assumption, that of transitivity, the preference relation becomes a preference ordering which allows a ranking of the objects of choice from best to worst. If the individual makes choices consistent with these two conditions, then the choices are said to be rational.

In order to investigate the choices of a group of rational individuals, some further concepts are required. First, a group is a collection of at least three individuals. The rules for aggregating the individuals' preferences into a group decision is called a constitution. There are two issues with respect to constitutions which are important for this paper: the first is the way in which individuals' preferences are used to arrive at a group decision, i.e. the rule of aggregation; and the second is whether the rule will generate a group choice.

One of the most commonly used rules is the majority rule. It appears to combine the preferences of the individual members of the group in a reasonable way, if the conditions of neutrality, responsiveness and anonymity are imposed. However, the actual choice made may not be satisfactory because this rule may lead to no choice at all. The latter unsatisfactory situation arises when the individuals' preferences are cyclic.[23] In an attempt to overcome the non-existence of the group's choice when that choice is made using majority voting, a variation is sometime advocated, namely, voting in two rounds. In this situation control of the order of voting can pre-determine the group's choice.[24]

This creates the possibility of controlling the agenda and influencing the outcome, which raises the issue of strategic voting, if the members of the group realize what is going on.[25]

There exist a few alternatives to the majority voting rule. The extent to which these rules are useful depends upon the conditions which they impose on the aggregation rule. If completeness and transitivity are imposed, then the majority rule may fail to provide a group choice, as shown in the example above. However, these are not the only possible conditions. Others include the weaker conditions of independence and unanimity.[26] With only these two conditions imposed upon the aggregation of the individuals' preferences, the only rational outcome for the group, i.e. one arrived at through a preference ordering, is to have a dictator make the decision for the group. This famous, but destructive, result is known as Arrow's Impossibility Theorem (Arrow 1963).[27]

In the context of decision making under uncertainty it is probable that individuals will have different intensities of preferences over the objects of choice. So far, the rules explored do not take account of this possibility nor can they because they are based implicitly on an ordinal scale. In order to incorporate intensity of preferences, it would be necessary to measure utility on a cardinal scale and also to allow interpersonal comparisons to be made amongst members of the group. This is what is done in a utilitarian framework in which the group's choice is the one which maximises the group's utility.

Limitations of Analysis

The simplicity of our analysis may be criticized on a number of grounds. Much debate surrounds the various assumptions of the utility theory when used to represent a group of individuals.

For a variety of reasons people find it difficult to optimize their decisions. Simon (1956) argues that in practice individuals have a limited range of alternatives, i.e. we do not know all the decision options available to us, and, even if we do, our conceptual limitations and time prevent us from comparing all of the options available. It is argued that cognitive limitations of the decision-makers force them to construct simplified models of the world to deal with decisions.[28] The result is that decision makers strive to attain some level of satisfaction within constraints that we do not necessarily optimize.[29] For example, it is unlikely in practice that preferences of committee members could be known at such a detailed level, suggested in our analysis, i.e. they each may not know the possible states of nature let alone the probabilities associated with each state.

Research in psychology also suggests that the way in which two options are framed or described can affect the preferences that individuals have for different options, although the options are in fact identical. The consequence of this is that people do not necessarily show transitive preferences.[30]

Another important limitation of our analysis is that if cycling is as pervasive as suggested, then it would be expected that the GTTAC's decisions would gyrate from meeting to meeting (e.g Mueller 1989:89). The fact that this does not happen suggests that other processes are occurring that convey some stability. Although regulations to the Act require the expert committee (GTTAC) to use majority voting,[31] it is likely that the committee works by consensus most of the time. However, when critical disagreements do arise, majority voting is used.

Conclusion

We have attempted to show: first, that division of powers between the national government and state governments has led to regulatory paralysis over GM canola; second, that cost-benefit analysis has a role in societal decision making; third, that qualitative risk assessment have some deficiencies when used to guide public policy and probabilistic risk assessments may be more useful in guiding decisions; and fourth, that even if the preferences of the individuals who comprise a committee are well-defined, it is no simple matter to aggregate these preferences in a meaningful way, i.e. a way which leads to a reasonable outcome from the group. It is certainly not necessarily the case, as our example shows that majority voting will lead to a reasonable outcome. Control of the agenda can pre-determine the outcome of a committee voting process and that process does not measure the strength of belief that each member has about the correctness of that belief.

We have attempted to contrast the decision-making process of the OGTR, which involves qualitative risk assessment, a cost-only approach and majority voting (based on an ordinal scale of preferences) with the feasible alternative of probabilistic risk assessment, the measurement of both costs and benefits and the use of monetary values to measure them (a cardinal scale). It is important for the quality of public policy-making in the area of risk assessment and the release of GM crops that these distinctions are more widely debated.[32]

There are a number of simple alternative voting procedures that the Committee could follow, such as exhaustive ballots (e.g. Mueller 1989:112). However, none of these approaches provides the Regulator with any information on the range of views expressed by the Committee. Since the aim of the Regulator is to make decisions based on an assessment of risk, and where there are different views about the size of the risk, it is essential that a range of views be expressed. A useful alternative procedure that reports a range of views is the Delphi system (Linstone 1999), first used by RAND, which provides a structured way to elicit judgements from expert panels using questionaries with feedback to panel members. In this way, the Regulator could obtain knowledge of the uncertainty (i.e., the vagueness of the relevant probabilities) associated with a particular recommendation.

Even given all these changes: resolving Federal State jurisdictional conflicts, incorporating benefits within a probabilistic risk assessment framework, and introducing the Delphi system for eliciting views instead of voting, approvals for transgenic crops will still depend on resolving the political situation.

Endnotes

[1] James (2003).

[2] Glover (2002).

[3] OGTR (2002a).

[4] Public attitude studies suggest that approximately 66 per cent of the population believe that genetic engineering applications of the type surveyed, could present serious risks. For details, see *Biotechnology Public Awareness Survey Final Report* (2003). http://www.biotechnology.gov.au/content/controlfiles/display_details.cfm?objectid=443164A1-7F7B-410C-BD068DA14499A560

[5] The Commonwealth Scientific and Industrial Research Organization (CSIRO), not the Office of the Gene Technology Regulator (OGTR), is the organization most respondents (40 per cent) believe is likely to provide reliable information. For details, see *Biotechnology Public Awareness Survey Final Report* (2003). http://www.biotechnology.gov.au/content/controlfiles/display_details.cfm?objectid=443164A1-7F7B-410C-BD068DA14499A560

[6] OGTR (2002a).

[7] Salisbury (2002).

[8] This report is available at, http://www.dpi.vic.gov.au/dpi/nrensr.nsf/93a98744f6ec41bd4a256c8e00013aa9/7ffeecb5f7229f0bca256eca0028583b/$FILE/Lloyd%20Part%203.pdf. Subsequent to the Government's decision, Monsanto decided to cease its research on this crop in Victoria.

[9] OGTR (2002b,c).

[10] OGTR (2002b), p.15.

[11] OGTR (2002b).

[12] By contrast, in the report to the Victorian Government, the expert (Lloyd, P.) used a social costs and benefits framework to arrive at his recommendations.

[13] USEPA (2000).

[14] Boardman *et al.* (1996).

[15] Kopp *et al.* (1997).

[16] Boardman *et al.* (1996).

[17] Lave (1996).

[18] Lave (1996).

[19] OGTR (2002b).

[20] Various authors have discussed these issues at length, e.g. Slovic *et al.* 1974a, 1974b, Slovic *et al.* 1975, 1979, Fischhoff *et al.* 1982, Slovic *et al.* 1982, Kahneman and Tversky 1984.

[21] OGTR (2002b).

[22] For example, see Linacre and Adès 2004.

[23] For example, suppose that there are three members of a group, M1, M2 and M3, and there are three choices available, namely, A, B and C. The preference orderings of the members are: $M1\,A>B>C$; $M2\,B>C>A$; $M3\,C>A>B$. Majority voting will fail. M1 and M3 rank A above B and, therefore, B cannot be chosen; M1 and M2 rank B above C and, therefore, C cannot be chosen; and M2 and M3 rank C above A and so A cannot be chosen. Another feature of this example is that the outcome does not satisfy the condition of transitivity. In choosing between A and B, A gets two votes; in choosing between B and C, B gets two votes; and because $A>B$ and $B>C$, then by transitivity, $A>C$. Yet majority voting reveals that $C>A$. This example illustrates the case that there may not exist any group choice based on the majority voting rule.

[24] To see this possibility, assume that in the first round it is decided by the agenda setter that a vote will be taken of A against B with the winner facing C in the second round. Using the members of the group above and their preferences, in the first round A will win and in the second round C will beat A to be the overall choice. However, had the controller decided that the first round should involve a choice between B and C, then the first-round winner would be B and, in the second round, A would be the group's choice. Finally, if the choice in the first round involved A against C, then C would win and go into the second round against B and would lose to B.

[25] For example, M1 might decide on the first round of a vote between A and B to vote for B, even although A is preferred to B, because in the second round, the individual knows that B will beat C and, for this individual, B is preferred to C. However, in a group of several individuals, and with secret ballots, it is unlikely that individuals in the group will have sufficient common knowledge to vote in this way.

[26] The independence condition means that the group's choice between A and B does not change in response to a re-ordering of an individual's preferences which leaves the alternatives A and B ranked as before. The unanimity condition means that if everyone in the group prefers A to B, then the group will choose A alone.

[27] As an alternative, if the condition known as anonymity is also imposed, then a slightly better result may be achieved by the group, although at the cost of its decisions not being transitive. This result is known as the Pareto rule: if there is no other choice which every individual in the group ranks above a specific one, then that specific one is the group's choice. However, this rule in practice is not particularly helpful because, unless every member of the group happens to agree, there is no single, group choice possible by the Pareto rule. Other rules for group decision making include Borda's rule and the patriarch rule (see Allingham 2002, ch. 6)

[28] Slovic *et al.* (1974b).

[29] Simon (1956).

[30] Slovic *et al.* (1982); Tversky and Kahneman (1982), Kahneman and Tversky (1984).

[31] GT (2002).

[32] A similar call has been made to incorporate economics into the Agreement on the Application of Sanitary and Phytosanitary Barriers of the World Trade Organization (see Anderson, *et al.*, 2001)

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Annex 1: Details of Agencies and Institutions Engaged in Work on GMOs

Abbreviation	Description	ULR
OGTR Regulator	Office of the Gene Technology	www.ogtr.gov.au
FSANZ	Food Standards Australia and New Zealand	www.foodstandards.gov.au
AQIS	Australian Quarantine Inspection Service responsible for food imports	www.aqis.gov.au
NRA	National Registration Authority	www.nra.gov.au
TGA	Therapeutic Goods Administration	www.health.gov.au
EA	Environment Australia	www.ea.gov.au
FDA	Federal Drug Administration	www.fda.gov
FSIS	Food Safety Inspection Service	www.fsis.usda.gov
EPA	Environment Protection Agency	www.epa.gov
APHIS	Animal and Plant Health Inspection Service	www.aphis.usda.gov

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Biotech Promotion Policy and Technology Transfer Issues: Evidences from Aquaculture and Marine Biotechnology

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Abstract: The paper elaborates upon the judicious utilization of aquatic resources for bioprospecting of useful products and processes and development of novel technology packages for entrepreneurs and industry. Some of the leads of national institutes working in fisheries and marine sector on technology development, dissemination and extension through the Department of Biotechnology (DBT) support have been highlighted apart from technology packages and patent leads. The technology packages adopted by the end users are responsible for the flourishing economy of the sector. Various strategic approaches in technology generation, product development, commercialization, patents and novelty protection have also been suggested.

Keywords: Technology Transfer, Aquaculture, Marine Product and Process Development, Patents, Biotechnology Policy, India

Introduction

In the present scenario, when exponential advancements in biotechnology are taking place, a large consumption market has already been created in biotech products developed locally or made available through imports. These include primarily the products of old biotechnologies, although there is a shift of preference visible in the marketing of modern biotech products too, especially in biopharmaceuticals, agriculture, industrial products, environmental bioremediation processes and aquaculture and marine sector. The indigenous consumption of biotech products has increased the scope of trade as well as of new investments in most of the biotech sectors. However, the products required for human and animal healthcare have

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dominated the scene due to their wider applications. It is estimated that the total turn over of recombinant biotech products produced locally is about Rs. 600 million while for healthcare products the total consumption is in the range of Rs 2500 million.

There is ample potential in the country's aquatic resources both in freshwater and brackish water for augmenting fish and shrimp production using aquaculture, thereby increasing foreign exchange earnings through shrimp export and generating adequate employment opportunities besides increasing farmer's income. Ever increasing population, its food requirement, besides the problem of malnutrition have necessitated an optimal use of renewable resources in order to increase food production from them by adoption of new technology. Aquaculture and marine biotechnology is one such area in the fishery sector where food production has been increased from the aquatic resources, not fully utilized hitherto by adopting newer technology. The marine sector can contribute a large revenue through emphasis on research and development.

The Indian Government has promoted modern biotechnology in all areas of scientific endeavours. Starting from development of infrastructure, strengthening of extramural R&D research in Indian institutions and by generation of skilled manpower in biotechnology the state has helped to foster the development of biotechnology products and processes as well as to transfer the institutionally developed technologies and indigenous knowledge to industry. Since its inception the Department of Biotechnology (DBT) has played a very important role not only in the development and transfer of indigenous technologies to industry, but has also played a pivotal role in the promotion of biotechnology in the country, in the protection of Intellectual Property Rights and in ensuring the implementation of biosafety regulatory issues during the developmental process.

There is a slow but steady progress in the shifting of preference in the use of machinery for the development and production of biotech products. Among the developments in biotechnology in modern times, Genetically Modified Organisms (GMOs), involving microbes, plants and animals providing various molecules for use in pharmaceuticals, agriculture, food as well as the environmental bioremediation and management, are noteworthy. The successful commercialization of technologies is highly rewarding, as the innovative biotech products have immense potential to generate profits and returns on investments, and thus impact the fortunes of companies in a very short span of the business period. The role of government agencies in promoting this emergent area is very important for the promulgation of various proactive policies, incentives and support to the biotech sector.

Promotion of Biotechnology through DBT

The growth of biotechnology in the country can be traced to the endeavour of the National Biotechnology Development Board in the Department of Science and Technology, Ministry of Science and Technology. It was not until late 1980s that the government's initiative in industrial policy change and the linked process of biotechnology development in the country gathered momentum with the establishment of an independent DBT by the Union Government. The main thrust of DBT has been to build competence in research institutions, provide industry-institution research collaborations to benefit society at large and stimulate international collaboration in socially relevant research in public-funded institutions. The initial emphasis in applications had been to promote traditional biotechnology. From 1987 onwards, certain specific areas have been taken up by the DBT for focussed development. These include the health care area, the development of immunodiagnostics, vaccines, recombinant DNA molecules, targeted drug delivery systems, microbial strain improvement and process optimization in antibiotics, and enzymes and bioactive molecules. In agriculture, apart from a focuss on crop plants, mass multiplication of elite planting materials by tissue culture techniques, development of hybrid high yielding seeds, region and crop-specific biofertilizers and biopesticides, and the development of transgenic disease-resistant and stress-tolerant plants were specifically taken up. In addition, in husbandry practices apart from perfection of embryo-transfer technology to develop high yielding milching animals like cattle and buffaloes, the major focus was on aquaculture and marine sciences and biotechnology. Development of recombinant organisms with high efficiencies of substrate conversion were emphasized under industrial biotechnology. Use of stress-tolerant microbial concentrates are being attempted for treating liquid effluents; concurrently planting of forest species of plants raised through plant-tissue culture are being attempted under environmental biotechnology.

During the past decade the strategies have been reoriented to promote modern biotechnology in preference to traditional practice.

Through a multidisciplinary approach, the DBT has been instrumental in encouragement of biotech research by teaming up with various other scientific ministries, for example, Health and Family Welfare, Environment and Forests, Agriculture, Commerce and Industry, Small Scale Industries and Agro and Rural Industries, Department of Science and Technology, Department of Scientific and Industrial Research, Council of Scientific and Industrial Research, Indian Council of Medical Research, etc. This has helped in the promotion of biotechnology research and establishment of many foci in the country for research in modern biotechnology, medicine and biology apart from promotion of bioinformatics. In a network approach the DBT has been in close coordination with all the scientific agencies while 5,000 to 6,000 scientists interact with the Department every year in various capacities. Such a wide ranging interaction with scientists, technologists and engineers could promote biotechnology development in the country substantially. The DBT has consolidated a number of programmes in the last decade which include demonstration, popularization and extension activities and also the creation of awareness about biotechnology amongst the general public. Aquaculture and marine biotechnology and bioresources are important areas for demonstration and the training programme. The Department has also established international collaborations with a large number of countries for the indigenous promotion of biotechnology. The major emphasis has been on multi-centric multi-agency programmes.

Technology Development, Transfer and Commercialization

The DBT has a proactive interaction with institutes engaged in developing biotech products and processes and fills the market information and requirements gap by means of continuous interaction between scientists of the institutes and with industry for technology packaging, apart from reorienting such teams to work with the industry. The logistical support of the DBT has enabled many ill-equipped institutions to develop technologies which have been validated independently as per their claims. This has helped the academia and industry partnership in appreciation of each other's problems and a search for quicker solutions in the common goal of technology development, transfer and commercialization issues. Incentives have been provided to the ground workers and inventors engaged in the technology development by the sharing of the proceeds as well as protection of their intellectual property. The product developmental work is being protected increasingly through the patent system while the awareness-building programme in the IPR issues by the DBT has started paying dividends. The industry had so far inadequate scientific capabilities to absorb and improve upon the technology it received which is now possible with the upgradation of their R&D facilities and infrastructure. The role of technology managers persently in catalyzing the development and transfer of technologies is now well appreciated both by the institutions as well as the industry with its proven usefulness to the society, which has gone a sea change.

Government Policies and Biotech Industry

The development of regionally-dispersed industries with manufacturing capabilities but without any perception of scope for their expansion and diversification adversely affected the industrial growth and lowered the production. This has also affected the foreign exchange reserves of the country. The central government, with the objective of developing a globally competitive industrial sector consequently took corrective measures by promulgating newer policies of planning, control of industrial capacities, regulation of locations of industrial units and approvals for foreign collaborations. Further, it adequately modified the previous developmental policies from July 1991 onwards. To attract foreign investors the Ministry of Industry further liberalized the licensing policy through the establishment of the Foreign Investment Promotion Board (FIPB) during 1997-98 and the Foreign Investment Implementation Authority (FIIA) in 1999 to facilitate the flow of foreign investment in the country. The biotech sector also got a boost with the liberalized policy and benefitted from an automatic registration process in industrial licensing. There is a 100 per cent rebate on R&D expenditure by a company and 125 per cent rebate on contract research through a public-funded R&D institution. These policies infused the corporate sector to set up their own R&D units to develop own technologies. Today, 100 per cent foreign equity investment is possible in all industrial sectors. In the pharmaceutical sector, 74 per cent foreign equity investment is automatic and over 74 per cent equity is also considered by the Union Government on a case-by-case basis to promote this sector. This has led to the establishment of technology parks in various sectors especially in knowledge-based industries such as drugs and pharmaceuticals, information technology including biotechnology. It is estimated that there are over 55 research and development laboratories in the public sector and that more than 20 are engaged in conducting research in the frontier areas of biotechnology in which the government has invested over Rs.10,000 million for creating R&D infrastructure and skilled manpower. The private sector that cannot invest large amounts to create their own sophisticated infrastructure to perfect their technologies can team up with the public labs for collaborative research. Thus the current liberalized policies have provided the necessary impetus to the entrepreneurs to set up substantial and competitive industrial units in the country with the necessary support from the union government. The government has increased greatly its proactive role for the industry in the matters of technology selection, technology evaluation, technology perfection and technology absorption by extending necessary clearances. These liberalized policies have made the market fairly competitive especially with the inflow of foreign direct investment. The indigenous research and development capabilities under the changed scenario have been improved to compete with the imported technologies.

Aquatic Resources: Stock and Utilization

In India, tanks and ponds occupy 2.85 million hectare of land, lakes and reservoirs occupy 2.05 million hectare of land, and there are 0.78 million hectare of derelict water bodies such as swamps, beels, ox-bow lakes, etc., 0.17 hectare km length of rivers and canals; and about 1.42 million hectare of brackish water land, lakes and estuaries. These resources have great potential. The estimated potential for fish production in the country, both marine and inland, is about 8.4 million tonnes comprising 3.9 million tonnes of marine and 4.5 million tonnes of inland fish production. Against this, the present fish production is about 6.18 million tonnes consisting of 3 million tonnes of inland and 3.18 million tonnes of marine. The annual production can increase if the available techniques are fully adopted and transfer of know-how and production of material inputs properly organized. In terms of cultivable species of fish/shellfish, the components are diverse to suit the varied ecological conditions of different water bodies as also to meet the regional preferences. With technologies available for breeding and culture of catfishes (*Clarias batrachus, Heteropneustes fossilis*) and murrels (*Channa* spp.) organized culture could be undertaken. Fish species like mahseer

(*Tor* spp.), hilsa (*Hilsa ilisa*), trout (*Salmo trutta*), *Ompok* spp., non-airbreathing catfishes like *Wallago attu*, *Mystus seenghala*, *Mystus aor* and *Pangasius pangasius* are being studied for incorporation into commercial culture practices. These rearing systems require various forms of intervention such as stocking, feeding, protection from predators, diseases, etc. and involve farm management. India has been paying greater attention to the aquatic resources by assigning importance to aquaculture during the last 2-3 decades. Aquaculture has acquired the status of one of the fastest growing sectors for increasing food production owing to the introduction of scientific fish/shrimp farming and artificial propagation for production and supply of quality seed. By virtue of this, India today occupies the second position, next only to China being the first in global aquaculture production, whereas in fish production it occupies the forth position. India earns over US$ 1.4 billion through its seafood export earning.

The Central Institute of Freshwater Aquaculture (CIFA) at Bhubaneswar, Orissa, the premier Institute for freshwater aquaculture under the Indian Council of Agricultural Research (ICAR) in the country, has over the years developed several technologies and packages of practices in different aspects of freshwater aquaculture relating to carps, catfishes, prawns and molluscs. With extension programmes and economic incentives during the last decade, fish culture that was once restricted to the Eastern states of West Bengal, Orissa and Assam, has become a major economic farming activity in states like Andhra Pradesh which has become an example for the rest of the country to emulate. With innovative practices like high stocking densities, water circulation and aeration, provision of feeds, etc. the production rates of 8-10 t ha yr have been achieved in the region as against the national average of 2 t ha yr. Thus, states like Andhra Pradesh, Punjab, Maharashtra, Haryana, Gujarat, etc. are taking up fish culture on a large scale, many with the objective of exporting the produce to fish-consuming states.

Aquaculture and Fish Breeding Technologies

While the technologies of induced carp breeding and composite carp culture gave a fillip to the freshwater aquaculture industry in the country during the sixties and the seventies, several new components are being added in recent years, with the aim of optimizing the productivity levels. The practice of fish culture is also being employed for treating wastewaters and agro-based industrial effluents like distillery wastes.

This adds a new dimension to the practice of aquaculture that is eco-restoring, environment-compatible and economical. Being basically a carp country, both the indigenous and exotic carps, viz., catla, rohu, mrigal, silver carp, grass carp and common carp account for a bulk of the production. Several other candidate species include *Labeo calbasu, Labeo fimbriatus, Labeo gonius, Labeo bata, Puntius pulchellus, Puntius kolus, Puntius sarana, Cirrhinus cirrhosa* and even minor carps that fetch a high price in the markets.

Different carp culture systems that have been standardized with minimum achievable production rates are composite carp culture (4-6 t/ha/yr), sewage-fed fish culture (3-5 t/ha/yr), weed-based polyculture (3-5 t/ha/yr), biogas slurry-fed fish culture (3-5 t/ha/yr), integrated fish farming with poultry, pigs, ducks, horticulture, etc. (3-5 t/ha/yr), intensive pond culture with feeding and aeration (10-15 t/ha/yr), pen culture (4 t/ha/yr), cage culture (10-15 kg/m^2/yr), and running-water fish culture (20-25 kg/m^2/yr). Intensification of culture systems is being standardized in pond culture, cage culture, pen culture and running-water fish culture/flow-through systems. A significant achievement in this direction has been the production of 15 tonnes ha yr in carp culture with high stocking densities, biofertilization, supplementary feeding, aeration and water replenishment.

The techniques of breeding and seed rearing in cases of catfish species, viz. Magur, *Clarias batrachus*; Singhi, *Heteropneustes fossilis,* having been standardized, their culture is increasingly being adopted. With standardized breeding and hatchery management practices in cases of freshwater prawns, *Macrobrachium rosenbergii* and *M. malcolmsonii,* high density nursery rearing and semi-intensive culture with a targetted production of 5 t ha yr with the giant freshwater prawn are envisaged. Prawn seed production in synthetic seawater and salt solution and seed production throughout the year under controlled conditions have been achieved in case of the riverine prawn.

Efforts in recent years have been directed towards increasing productivity from the existing systems as well as countering the problems emerging with the intensification of aquaculture practices. Advancement of carp maturity to the month of March over the prevailing period of June-July and breeding of the same individual four times a year with gaps of 45 days between two successive breedings have made it possible to provide fish seed almost throughout the year. Successes achieved in cryopreservation of spermatozoa have eliminated the need for maintenance of male broodstock and attempts at cryopreserving the ova and the embryos are presently underway. With alternatives to crude pituitary gland extract available for induced breeding, sequencing and synthesis of GnRH are being carried out in order to evolve an indigenous replacement for the imported products. Having produced integeneric hybrids of carps as also gynogens and androgens, the application aspect pertains to the sterile triploid grass carp that could be stocked in irrigation canals for control of aquatic vegetation. Genetic assessment of riverine stocks of rohu for selection is an ambitious programme that would provide superior stocks with sustained vigour and an improved rohu is about to be released.

Production of cultured freshwater pearls has been a major achievement in recent years and is a step towards diversification of commercial aquaculture. With different stages of collection and conditioning of freshwater mussel, *Lamellidens* spp., preparation of mantle tissue, surgical implantation of graft and appropriate nuclei in the internal organs of the recipient mussels, post-operative care and culture before harvesting of pearls having been standardized, different kinds of pearls like regular, irregular, half-round pearls and pearl images have been produced.

The investigations of nutritional requirements of fish/shellfish species take into consideration the specific requirements of amino acids, vitamins and minerals for formulations of balanced diets, while commercial diets like the one for carp feed, CIFACA have been released. Apart from investigations on the microbial pathogens and parasites, chemical formulations like CIFAX have been prepared for treatment of epizootic ulcerative syndrome in fishes. Aquaculture biotechnology comprising aspects of genetic improvement of fish/shellfish, synthesis and use of hormones, biofertilization, bioprocessing or organic matter, serodiagnostics and immunoprophylaxis, etc. is expected to play a major role in improving the aquaculture productivity in the years to come.

With concerns regarding pollution control and environmental management, it is necessary that farming practices incorporate these aspects in management. It may be mentioned that freshwater aquaculture is not only highly compatible with any of the farming systems, crop-based or livestock-based, but also that these systems could receive, process and treat a number of organic wastes, mainly domestic sewage. This aspect needs to be exploited to a greater extent to develop resource recovery-based waste treatment measures through aquaculture. In Indian freshwater aquaculture, sustainability of the production system is of a high order. Being organic-based it has to be the watchword in the planning of development programmes.

Linkage Development and Technology Transfer

Strong linkages between research organizations and development agencies are highly essential not only to transfer the technologies from the laboratory to the field, but also to obtain a feedback on the prevalent problems and technology adoption levels. Weak extension machinery has often been identified as the case for low production levels (see Table 1). With the country having varied agro-climatic zones, it is necessary that the technologies are subjected to multilocational testing and suitable modifications are incorporated in the packages of practices in different regions. It is relevant to mention here that the CIFA, Bhubaneshwar is presently developing a national freshwater aquaculture development plan for the country on a district basis, to serve as a blue print for enhancing aquaculture productivity from the present national mean level of 2 t/ha/yr to 3-5 t/ha/yr. Annex 1 provides a detailed list of such initiatives.

Through the Mission Mode programme implemented in coastal and inland states, infrastructure in terms of prawn complex comprising hatchery, feed mill and farming system was set up for freshwater prawn, *Macrobrachium rosenbergii* and brackish water species. This is being used for regular seed production. A multi-species prawn hatchery was established, both for penaeid and non-penaeid species and different grades of feed were produced to stock the ponds and reservoirs and supply to the end users. A freshwater prawn production of 1.5 to 2.0t/ha was achieved from the grow-out culture operation. Farmers and the entrepreneurs adopted this technology.

Protocol for Technology Transfer and IPR Issues

The Ministry of Science & Technology, Department of Biotechnology, Government of India has brought out guidelines explaining the detailed protocol on technology transfer and IPR-related issues for the benefit of R&D institutes, scientists and project investigators (PIs). This is to enable such pioneers to file patent application for their invention and to motivate transfer of the technology for commercialization. The benefits of this

Table 1: Technologies Developed under Aquaculture and Marine Biotechnology Programme

S.No.	Technology	Institute Developed	Industry Procured
1.	A heat-killed whole cell vibrio vaccine	College of Fisheries, Mangalore	Mangalore Biotech Laboratory, Mangalore
2.	To overcome the problem of viral diseases in shrimp aquaculture and for simultaneous detection of WSSV and MBV, development of highly sensitive method. "Combi kit - WSSV, MBV" a test kit, for specific detection of pathogens	Department of Microbiology, UAS, College of Fisheries, Mangalore	Mangalore Biotech Laboratory, Mangalore
3.	Polyclonal antibody based immunodiagnostic kits for detection of different bacterial pathogens in finfish and shellfish	Central Institute of Fisheries Education	GlaxoSmithKline Pharmaceuticals, Mumbai
4.	Polyclonal antibody-based immunodiagnostic Assay for the detection of white spot syndrome virus	Anna University, Chennai and CAH Abdul Hakeem College, Malvishram	Posiden Biotech, Chennai
5.	Bioreactors for prawn hatchery	Cochin University of Science and Technology	M/s Oriental Consultants, Coimbatore
6.	Monoclonal Antibody-based Diagnostics – RapidDot kit	College of Fisheries, Mangalore	Under Commercialization

Source: Compiled by the Author.

process learning is the access to rewards through royalties for the inventions made in various sectors of biotechnology including aquaculture and marine biotechnology. There are several patents filed in this area (see Annex 2).

(i) Benefits to Implementing Agencies

With the protocol to be followed, the funding agencies are encouraging the institutes to protect their inventions on the IPR generated through R&D efforts. It must be ensured that the patent is assigned in the name(s) of the inventor(s) and that this is entered in the register of patents as the proprietor of the patent. Necessary steps are to taken for commercial exploitation of the patent on an exclusive/non-exclusive basis and to permit the investor(s) to retain the benefits and earnings out of IPR and also to determine the share of the inventor(s) and the other person(s) from the actual earnings, which shall be limited to one third of the actual earning.

(ii) Benefits to Institutions and Industrial Concerns

IPR may be generated through joint research by institute(s) and industrial concern(s) through joint research owned by them, as mutually agreed by all the parties through a written agreement. The institute and industrial concern may transfer the technology to the third party for commercialization on an exclusive/non-exclusive basis and the third party can get the product, exclusively licensed to market and be manufactured in India. Joint owners are allowed to share the benefits and earnings arising out of commercial exploitation of IPR. The institute determines the share of the inventor(s) and other person(s) from such actual earnings, which should not exceed one third of the actual earnings. The institute shall create a patent facilitating fund, in which not less than 25 per cent of the earnings through technology transfer/ IPR and the same can be utilized by the institution for innovation and the filing of new patent applications, protecting their rights against infringements for creating awareness and building competence on IPR and related issues.

(iii) Benefits to the Funding Agencies

Institution(s)/agencies, where the funding is being provided, are required to provide details of the patent obtained, benefits and earnings out of the IPR and the turn-over of the product periodically to the funding ministry/department. The funding agency can also be kept informed of the market potential of the product and its sustainability in the longer run. The receiving agencies shall keep the funding agencies informed of the utility of the funds provided, the viability and the outcome. The institute shall acknowledge the DBT for the patent obtained/technology transferred. The government shall have a right to a royalty free license for the use of the Indian patent for the purposes of the government of India. The guidelines are being reviewed and revised form time to time.

(iv) Patent Facilitation Cell

A single window awareness-cum-facilitation mechanism is also functioning in the Department of Biotechnology. This creates awareness and understanding on IPRs for the benefits of scientists and researchers. It also organizes workshops, seminars, conferences, etc. at all levels and for introducing patent information as a vital input in the process of formulation of R&D programme in biotechnology and provides patenting facilities to biologists and biotechnologist in the country for filing Indian/foreign patents. The nodal agency also keeps a watch on developments taking place in the area of IPR and addresses various important policy issues for scientists and the biotech industry. The patent facilitation cell also encourages the PIs to submit applications in proforma for examining their inventions and other IPR-related issues. National agencies like the National Research Development Corporation (NRDC) and Bioconsortium India Limited (BCIL) or any other attorney of the approved DBT panel are being appointed on a felt need basis for assessment and advocacy of the patents for filing, both nationally and internationally. The DBT committee/attorney, after assessment, recommends the patent for filing/granting in India, in Asian countries, and globally. The fee/consultancy of the application/attorney is met by DBT. The DBT has filed so far more than 100 Indian/international patent applications, out of which a dozen patents have been granted.

Technology Transfer Options Under Joint Collaborative/Bilateral Projects

The time has come to strengthen R&D in aquaculture and marine biotechnology through judicious efforts and joint collaborative R&D projects. The projects could include the following: breeding and seed production programme in non-conventional species, namely, groupers, seabass, mullet, marine ornamental fishes, penaeid and non-penaeid prawns, crabs, lobsters and mollusks, etc.; culture of live-feed organisms including Artemia cultivation; programme on selective breeding and development of disease-resistant brood stock; diagnostics and vaccines; marine genomics and transgenics; and cage culture technology in marine species (feed formulations and disease management). The establishment of well organized R&D facilities along with provision for transfer of technology and extension system for the above is the need of the hour. Prior to technology transfer, its consistency, economic viability, social acceptance and environment consciousness have to be critically reviewed. It is difficult to identify and eliminate the evils of aquaculture without setting up standards of transfer of proven technology. A new institute in ICAR or the government sector can be formed to carry out R&D connected with seawater-based aquafarming, employing skilled technical manpower with sound financial support for effective technology transfer, technology development, joint IPR and commercialization. Exchange of knowledge through joint workshop and training of scientists

It expected that in future many technologies will be developed in the Indian R&D institutions and that these would be transferred to the industry with their absorption and commercialization. Success in the commercialization of such technologies may be strengthened by learning from our failures and by taking corrective steps in all sectors of technology development, its transfer and deployment through commercialization. The Department has been playing a responsible proactive role for the promotion of biotechnology in the country since its inception and would continue its efforts. DBT has also set a good standard in venturing the aquaculture technologies for commercialization through R&D investments.

Conclusion

India has a long coastline (8129 km) including shelf area and huge marine and brackish water resources. Natural product development for marine resources are very promising, especially for drugs and pharmaceuticals, novel enzymes and chemicals, bio-molecules, biomaterials, products of food and industry applications, bioremediation and probiotics, etc. As the presently available drugs are reported to be ineffective due to development of multi-drug resistance, research may think of a new source, which is marine-based and could be a potent and viable option. By adopting the modern technologies for fisheries, production will be increased manifold. This will also ensure improvement in the socio-economic conditions of the targeted beneficiaries and also help them to generate additional income for their livelihood. Realization of the potentials of the freshwater aquaculture sector would greatly add to the nutrition, employment and economy. The sector requires further support in terms of extension for technology transfer and financing of core activities.

Aquaculture and marine biotechnology is a major area for promotion, as it has a large scope for product and process development. Numerous projects are being funded by an independent Task Force set up by the DBT. The development of culture technology in new aquaculture species and the factoring in of techno-economic viability consideration also forms part of the programme. This is relevant for its direct application to society through technology development, dissemination and adoption for the benefit of coastal and inland people. Various natural product development projects are being supported through funding mechanisms after rigorous review and monitoring.

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Annex 1: Technologies Developed

- Culture technologies for tiger shrimp, freshwater prawn and carp polyculture for higher production.
- Freshwater pearl production.
- Hatchery technology for clam, mussel and freshwater prawn seed.
- GnRH analogues as fish spawning agents.
- Process for EPA/DHA production using marine fish tissue and oils.
- Process for production of *Tachypleus amoebocyte lysate* (TAL).
- Bio-conversion feed for aquaculture.
- Process know-how for fermented fish viscera and poultry intestine silage.
- Feed technology for semi-intensive/intensive prawn aquaculture
- *Eucheuma* seaweed cultivation.
- A scale-up process for production of bacteriological grade agar.
- Immunostimulants for shrimp.
- Diagnostic kit for white spot shrimp virus.
- Monoclonal antibody-based diagnostic kit for white spot shrimp virus.
- Diagnostics for detection of fish pathogens for *Aeromonas*, *Pseudomonas*, *Vibrio* and *Edwardisiella* spp.
- Bioreactors for penaeid and non-penaeid shrimp hatcheries.
- A chemical mixture for EUS treatment in fish.

Annex 2: Patents Developed and Filed

- Process for synthesis and formulation of GnRH - a technology for fish spawning agents.
- Production of PUFA enriched artemia diet for shrimps.
- Novel process for the extraction of antifouling compounds from the horseshoe crab.
- Bioreactor for nitrifying water in prawn hatcheries.
- Development of oligonucleotide primers for detection of White Spot Shrimp Virus (WSSV).
- Sequences of a portion of the genome of whitespot syndrome virus of shrimp.
- Method for production of carrageenan and liquid fertilizer from fresh seaweeds.
- Improved process for producing enriched EPA concentrates.
- Process for preparation of fermented silkworm pupae silage useful as an ingredient in animal feeds.
- New and improved process of preparation of *Tachypleus Amoebocyte Lysate* from Indian Horseshoe crab, *T. gigas*.
- Designing and fabrication of an indigenous fermentor for nitrifying water in prawn hatcheries.
- Transformation of the solution phase heme-Histidine rich protein based antimalarial drug discovery method to the solid phase.
- A new molecule for cardiac development promoting activity.
- Cardiac development promoting activity of perivitelline fluid of embryos of Indian Horseshoe crab, Tachypleus gigas (Müller).
- Development of aqueous extracts having anti-WSSV property from mangrove plants endemic to Indian coastal zones and their administration as prophylactics to protect shrimps from the virus.

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Biosafety Capacity Building in Developing Countries: Evidences from India

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Abstract: The present paper discusses about the need for the capacity development in the area of biosafety at the backdrop of the Cartagena Protocol of Biosafety. India is implementing a GEF-World Bank Capacity Building Project on Biosafety which has four components, viz strengthening intuitional and legal framework, to improve capacity for risk evaluation and management, to strengthen laboratories/institutions for analytical delectation of LMOs, and establishing a Biosafety Clearing House (BCH) for information sharing and public awareness. The Capacity Building need to be science based and maintain a balance between productivity, competitiveness and environmental concern.

Keywords: LMOs, Biosafety Clearing House, Capacity Building, Developing Countries, India.

Introduction

Global Environment Facility (GEF) Council, at its meeting held in November 1997, in response to the Article 8(g) of the Convention on Biological Diversity, approved a pilot project to promote a comprehensive understanding and approach to biosafety by countries in order to safeguard biological diversity under *in situ* conservation against possible adverse impacts from Living Modified Organisms (LMOs) with novel traits resulting from biotechnology. The project was to improve and strengthen national instruments for environmental management. As a follow-up of the CBD, in January 2000, the Cartagena Protocol on Biosafety was signed with the aim to ensure an adequate level of protection. The prime mechanism for its implementation was the development of National Biosafety Frameworks. More than 130

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countries adopted the Biosafety Protocol on 29th January, 2000, in Montreal, Canada. The Protocol entered into force on 11 September, 2003.[1]

Article 22 of the Cartagena Protocol on Biosafety[2] deals with "Capacity-Building" which requires that the Parties shall cooperate in the development and/or strengthening of human resources and institutional capacities in biosafety, including biotechnology to the extent that it is required for biosafety, for the purpose of the effective implementation of this Protocol, in developing country Parties, in particular the least developed and small island developing States among them, and in Parties with economies in transition, including through existing global, regional, sub-regional and national institutions and organizations and, as appropriate, through facilitating private sector involvement.

Also, it mentions that cooperation in capacity building shall, subject to the different situation, capabilities and requirements of each Party, include scientific and technical training in the proper and safe management of biotechnology, and in the use of risk assessment and risk management for biosafety, and the enhancement of technological and institutional capacities in biosafety. The needs of Parties with economies in transition shall also be taken fully into account for such capacity building in biosafety. Modified organisms released in, or moved into or out of, areas within their national jurisdictions would have to be monitored carefuly.

Components of Capacity Building

The Protocol envisages for capacity building, *inter alia,* in the following areas:

- Risk assessment, risk management, detection of LMOs, monitoring of LMOs.
- Institution building, including labs and equipment for testing LMOs.
- Scientific, technical and institutional collaboration.
- Human resources development including training in scientific skills.
- Facilities and methods for inspection and ID of LMOs.
- Awareness, education and participation.
- Information sharing and data management including participation in the BCH.

Some of these needs envisaged by developing countries in various meetings are related to biotechnology and biosafety. Developing countries are trying to respond to the legitimate concerns in order to continue their work on biotechnology taking into account appropriate safety measures with an aim to establish a safety framework on human health and the environment. Capacity development needs to be initiated to address the following concerns:

- Safe use of biotechnology, including a wider set of issues involving plant and animal health;
- Developing research capacities through human resource development;
- Capacity for making informed decisions/choices on establishing institutions, developing legislation, development and adequate use of methods on risks assessment and management, certification and labeling, etc.

One of the important facets of the capacity building is the public participation, which needs to reflect different situations, capabilities, and stages of development of each country. Governments, therefore, have to address a range of choices at each stage of the process. Capacity building would be in various manners, viz. information gathering and distribution/dissemination through appropriate media and formats to which various stakeholders can easily access since public awareness and participation are intrinsically linked. Sharing information to enhance the capacities of various stakeholders would raise awareness, which will not only enable citizens to consider various facets to firm up their opinions but also make the industries and policy makers address the issues more judiciously.

Identifying stakeholders for capacity building requires careful analysis and consultation among those who are involved initially to identify all who need to be part of the process to reach a necessary balanced consensus. In most geographical and social contexts, attempts to share information and have consultation with the participants from the public will engage some sections of the public more easily than others. Besides the participation of government departments in the deliberations, it is also important to engage the civil societies and other leading institutions working in the area for a transparent but judicious opinion. This helps to ensure that relevant knowledge is included in the process, that the process is credible to participants and the affected parties. This will enhance overall government commitment to a process.

Public participation in environmental decision-making is important to the success of any policy as has been reflected in many international instruments. For example, Rio declaration states that "environmental issues are best handled with the participation of all concerned citizens, at the relevant level." At the national level each individual shall have appropriate access to information concerning the environment and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy should also be made available. This further reflects that it would be crucial to engage legal persons and public at large in discussions about what types of regulation they feel are necessary and appropriate for biotechnology and also for some understanding of the legal and policy issues regarding how decisions will be made.

In most of the common perception of the public on the biotechnology and biosafety "public ignorance" and "misunderstanding" have been on the forefront. This leads to 'failures' to comprehend the benefits of biotechnology vis-à-vis biosafety, which often are attributed to the public that is characterized as poorly informed and overly influenced by inaccurate reporting of complex scientific and technical questions. Therefore, in this connection national and regional awareness-raising workshops and seminars targeting particular stakeholders would generate adequate capacities. These programme may address biosafety and biosafety regulation, apprise regulators, inspectors, laboratory workers and company officials about risk assessment, risk management and their legal responsibilities. Communication technologies such as internet, discussion forums and email news-groups would be of added advantage. National and local media including newspapers, radio and television can be used to inform people about biotechnology and biosafety issues as well as to publicize new developments, meetings and events.[3]

The International Process

In order to address these needs, the governing body of the Protocol (the Conference of the Parties serving as the meeting of the Parties to the Protocol, or COP/MOP); at its first meeting in February 2004 in Kuala Lumpur (COP/MOP-1), invited Parties, governments and relevant organizations to review the information on needs and priorities submitted to the BCH. When developing assistance programmes COP/

MOP-1 and in MOP-2. It also adopted an action plan for building capacity, which describes possible roles for various actors in building capacity. Following responsibilities/roles were given to the scientific and academic institutions as identified in the Action Plan:

- Promoting public awareness
- Implementing training and education activities
- Developing centers of expertise
- Implementing exchange and scholarship programmes with developing countries
- Cooperating on research and information-exchange
- Participating in capacity-building initiatives in relation to implementation of the Protocol
- Providing co-financing for capacity-building activities

The COP/MOP also adopted a coordination mechanism for implementation of the action plan. Under the coordination mechanism, which is administered by the Secretariat of the Convention on Biological Diversity, several databases are hosted on the Biosafety Clearing-House. These include the database on capacity building needs and priorities and possible measures for addressing them. It encourages Parties and Governments to develop strategies for capacity building in biosafety, and make provisions for the needs for capacity building in different components of National Biosafety Framework in order to facilitate proactive, systematic and coordinated approach addressing the capacity needs and gaps of different countries. Further, it encourages Parties and Governments to address the issues of sustainability of capacity building by designing in their capacity building plans and programmes as part of their regular national programmes. COP/MOP-1 and two urged Parties, Governments and relevant organizations to register information in the BCH on relevant capacity building initiatives. It has been felt that most initiatives focus on human resource development, information-sharing and institutional development, while there are gaps in the areas of identification of LMOs, risk management, and technology transfer.

Development of scientific expertise in biosafety, including capacity for research and technical support, is crucial for developing countries, which will contribute to effective negotiations on biosafety issues in future. Full and effective deliberations on scientific aspects of the Protocol can only be achieved if scientific expertise is representative of both developed and developing countries.

Recognizing that capacity-building is a complex issue, which requires urgent as well as long-term sustained efforts , to assist developing countries in order to comply with biosafety issues, GEF has carried out an assessment of the capacity building programmes being implemented as well as that of the future institutional and implementation arrangement.[4] The assessment recognized that issues like geographic coverage, several key areas such as administrative systems and risk management, and providing indepth training need to be addressed adequately. These gaps could pose a serious challenge to successful implementation of the Protocol. The preliminary recommendations derived from the assessment addressed general capacity-building issues, which include the gaps and the sustainability of projects and cooperation, and called for more support from a wider variety of donors and more support to developing countries to assess their priorities. More focus on long-term training and support was felt necessary for administrative systems, risk management and monitoring and information systems. The sustainability of projects needs to be ensured at the planning stage. The existing action plan should be complemented by the support for the Biosafety Clearing House. This report was discussed in the CoP-MoP-3 (UNEP/CBD/BS/COP-MOP/3/INF/12) and action plan developed.[5]

The GEF began its initial financing of capacity-building activities for biosafety in 1997 when the GEF Council approved allocations to 18 countries under a pilot phase. In 2000, the council approved the GEF Initial Strategy for Assisting Countries to Prepare for the Entry into Force of the Protocol. In accordance with the strategy, the council approved an umbrella-type global project, including up to 100 countries, for the development of national biosafety frameworks (NBFs) and individual projects in 12 countries for the implementation of such frameworks.[4]

The Biosafety Clearing House (BCH) aims at to provide a central, needs-driven, and neutral information resource to all the Parties to the CBD. Information on the import and export of LMOs is to be supplied by Parties through the BCH. Broad participation and easy access are the major priorities. Therefore, the database of information and resources can be accessed via the internet. The BCH provides access to the CBD's official records and key texts, case studies, national and other reports, information about relevant programmes, and a roster of government-nominated scientific and technical experts. Presently the BCH for India is being developed. It is intended to facilitate the exchange of scientific, technical, environmental and legal information and experience relating to LMOs.

Biosafety Capacity Building in India

Environmental protection and the conservation of natural resources emerge as key national priorities in India in the wake of various summits on environment. India has been able to develop a stable organizational structure for environmental protection in the country. Laws, policies and programmes have also been developed to meet the goals of improved environmental management. Several policy instruments have been enunciated and various action programmes have been developed and implemented by the Ministry of Environment and Forests (MoEF) in order to address the problems of environment and development and to consider several cross-sectoral issues having direct bearing on conservation as well as sustainable uses of national resources including forestry and wildlife.

Keeping these in view, India is implementing a GEF-World Bank Capacity Building Project on Biosafety. The capacity building project will enhance the India's national capacity in order to implement the Cartagena Protocol on Biosafety. India already has in place a biosafety regulatory framework in the form of the Rules for Manufacture, Use, Import, Export and Storage of Hazardous Micro-organism/Genetically Engineered Organisms or cells, 1989[6] notified under the Environment Protection Act, 1986. This project will address the capacity building needs of the country for implementing the national biosafety framework related to the transboundary movement of LMOs in the context of the Cartagena Protocol and coordination of the implementation of the BCH.

Specifically, the project will develop national capacities in biosafety requirements to: (i) strengthen the legislative framework and operational mechanisms for biosafety management in India; (ii) enhance capacity for risk assessment and monitoring; (iii) establish the biosafety database system and Biosafety Clearinghouse Mechanism; and (iv) support centers of excellence and a network for research, risk assessment, and monitoring. The development of national capacities in these areas will enhance the national capabilities for implementation of the biosafety issues. The major objectives for GEF support would be to improve capacity across ministries and among key stakeholders to analyze, inform, and make decisions to reduce potential risks related to LMOs, increase benefits to society, and protect biodiversity.

India, under the GEF-World bank Capacity Building Project, has undertaken various capacity building activities[7] and has also launched it is BCH which is interoperable with the central portal and could be visited at www.indbch.nic.in.[8] However, the immediate objective is to augment the capacity and ensure effective coordination between the responsible agencies to assess and manage risks associated with the transboundary movement of LMOs. This will be achieved through the strengthening of the biosafety framework with the necessary regulations, enhanced technical capacity and enforcement and monitoring capacities as well as a well-managed information and coordination network. The country will build sufficient capacity to assess and manage risks associated with the trans-boundary movement of LMOs through the strengthening of the legal and regulatory frameworks, enhanced institutional capacity and effective communication strategies. Knowledge and methodologies on biosafety are being shared and transferred to the State agencies through training programmes conducted across the country.[9]

Endnotes

[1] http://www.biodiv.org

[2] CBD (2000).

[3] DFID and GEF (2003).

[4] GEF (2005).

[5] http://www.biodiv.org/doc/meetings/bs/mop-03/official/mop-03-15-en.pdf

[6] Rules for Manufacture, Use, Import, Export and Storage of Hazardous Microrganism/Genetically Engineered Organisms or Cells. 1989 notified under the Environment Protection Act, 1986.

[7] www.envfor.nic.in/divisions/csurv/biosafety/default.htm

[8] www.indbch.nic.in

[9] MoEF (2006).

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Stem Cell Research in India: Emerging Scenario and Policy Concerns

Alka Sharma*

Abstract: In India, stem cell programmes have been initiated with the aim of promoting both basic and translational research in view of its potential applications. Strategy for promoting stem cell research (SCR) in the country is gradually taking shape. The key components of the strategy are: creation of centres of excellence (CoE); virtual network of centres; generation of adequate human embryonic stem cell (hESC) lines; human resource development through training, short and long-term overseas fellowships, etc. The-short term goal is to study the biology of all types of adult stem cells and in parallel evaluate its safety and efficacy in animal models. The Government of India has provided support to establish a Centre for SCR to carry out basic and translational research; training centres to provide training for both embryonic and adult stem cells; facilities in medical schools to handle stem cells; clinical research on myocardial infraction and stroke for safety and efficacy study; etc. Over 30 institutions, hospitals and industry are involved in SCR in the country. The government has invested about 8.0 million US$ for SCR in last two years. Support to small and large biotech companies is also being considered through the Research "Small Business Innovative Initiative (SBIRI)" scheme. Draft guidelines for SCR in the country have been formulated and the same is currently being placed for public debate.

Keywords: Stem Cell, India, Regulation

Introduction

Over the past few years, human stem cell research (SCR) has emerged as a new and exciting field in the life sciences being novel in its potential for clinical applications. Stem cells are precursor, unspecialized, undifferentiated cells capable of self proliferation, migration and differentiation. In the simplest form, the stem cell is an immature cell that has the capability to differentiate into any possible mature cell. Based on the sources, it is categorized into embryonic stem cells, adult stem cells and cord blood stem cells.

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The embryonic stem cell (ESC) is the 'mother' of all other cell types in the body and is derived from early stage of the human embryo, i.e. blastocyst. Blastocyst formation takes place after four days of fertilization. The blastocyst has an outer layer of cells while inside it has a hollow sphere with a cluster of cells called the inner cell mass. These inner mass cells are pluripotent in nature and may undergo further specialization into stem cells and give birth to cells having a particular function. These cells have the capability to turn into different types of tissues in the human body.

Adult stem cells may be derived from the bone marrow, peripheral blood, tissues, muscles, cardiac tissues, cartilage, brain tissues, etc. The adult stem cells are haematopoitic, non-haematopoitic and organ specific stem cells. Haematopoitic stem cells are blood-forming cells isolated from the bone marrow. Non-haematopoitic stem cells are mesenchymal stem cells (MSCs) and are present in many tissues of adult cells, i.e. bone marrow, cord blood, fat, bone, placenta, lung, liver, etc. These cells are pluripotent and non-immunogenic in nature. They are not patient specific and have a tendency to home to sites of inflammation.

The most important characteristics of MSCs is their ability to differentiate into several cell lineages such as cartilage, bone, active tissues, etc. to treat various diseases. Because of this unique characteristics, MSCs possess enormous potential for allogenic transplantation. MSCs may be isolated from various sources from normal healthy volunteer donors and manufactured under strict cGMP conditions. These cells may be characterized for research purpose as well as for its clinical applications in an allogenic setting.

In addition, stem cells may also be isolated from the umbilical cord blood. Much like the bone marrow, cord blood is one of the richest sources of stem cells. Cord blood stem cell research is being conducted for potential future use in the treatment of certain auto-immune disorders, neurological disorders, muscular/cartilage diseases, stroke, etc.

Any disease in which there is tissue degeneration may be a potential candidate for stem cell therapies, including conditions and disabilities as Parkinson's and Alzheimer's diseases, spinal cord injury, stroke, burns, heart disease, Type 1 diabetes, osteoarthritis, rheumatoid arthritis, liver diseases, retinal regeneration, limb ischemia, hair cell regeneration, etc. Stem cell therapies, like other tissue transplants, face the problem of immune rejection. Alternatively, using the patient's own cells and tissues will overcome the issue of immune rejection. The researchers have explored four possible ways to use mesenchymal stem cells for clinical applications, i.e. implantation of MSCs at site for localized diseases, systematic transplantation, combining stem cell therapy with gene therapy and use of MSCs in tissue engineering protocols. Clinical trials (mostly phase I) are being conducted using MSCs for osteogenesis imperfecta, large bone defect, myocardial infarct, chronic non-healed skin wound, etc. A lot more basic information about stem cells and their behaviour are required before they can be used for treatment.

Extensive basic research is required for standardization of methods for the isolation of embryonic and adult stem cells from various sources. Future prospects for embryonic stem cell research include the following: generation of therapeutic grade cell lines; identification of human embryonic stem cells (hESC) growth factors; controlled differentiation, i.e. generation of specific cell population; study of fundamental changes in cell cycle control that occurs during embryonic stem cells differentiation; maintenance of stem cell in undifferentiated stage; regulation of differentiation of ESC; pluripotency and differentiation of established cell lines; standardization of animal free defined culture conditions; developmental potential of human versus mouse ESC; standardization in use of specific stem cells to specific organ systems, etc. In addition, ESC could also be used for toxicology tests and may be valuable tools for traditional drug discovery.

Clinical research using stem cells in animals and humans is an emerging science. Use of *ex-vivo* expanded stem cells has been identified as new use of drug as per FDA, USA, i.e. investigational new drug (IND). IND covers issues related to cells, animal studies and clinical trial. The cell issues include among other: the source, number, purity, appropriate stage, optimum condition and criteria for harvesting stem cells; mechanisms of harvesting, standardization of procedures for harvesting, purification and characterization, also standardization of doses in terms of concentration and number of stem cells for each application and minimal manipulation of cells for clinical use. The animal studies issues include small vs. large animal, human to rat or rat to rat or both, length of safety studies, whole animal histopathology, defining delivery, dosage study, etc. Clinical trial issues cover the number of patients to be enrolled in rare diseases, inclusion and exclusion criteria, randomization, non invasive tracking of cells, lack of definitive guidance, etc. Good animal models are required to address the issues of

Table1: Institutes, Hospitals and Industries involved in Stem Cell Research

Embryonic stem cell research	• National Institute for Research in Reproductive Health, Mumbai
	• National Centre for Biological Sciences, Bangalore
	• National Centre for Cell Science, Pune
	• National Brain Research Centre, Manesar
	• Rajiv Gandhi Centre for Biotechnology, Thiruvanthapuram
	• Centre for Human Genetics, Bangalore
	• Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore
Heamatopotic stem cells and bone marrow mononuclear cells	• Christian Medical College, Vellore
	• Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow
	• Post Graduate Institute of Medical Education & Research, Chandigarh
	• Manipal Hospital, Bangalore
	• All India Institute of Medical Sciences, New Delhi
	• National Centre for Cell Science, Pune
	• National Institute of Immunology, New Delhi
	• Indian Institute of Science, Bangalore
	• Indian Institute of Technology, Chennai
	• Research & Referral Hospital, New Delhi
Limbal stem cells	• L.V. Prasad Eye Institute, Hyderabad
	• R. P. Centre, AIIMS, New Delhi
	• Regional Institute of Ophthalmology, Kolkata
Neural stem cells	• National Brain Research Centre, Manesar
	• National Institute of Mental Health and Neurosciences, Bangalore
	• National Centre for Cell Science, Pune
	• University of Hyderabad, Hyderabad
Mesenchymal stem cells	• Christian Medical College, Vellore
	• Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow
	• Manipal Hospital, Bangalore
Liver stem cells	• Centre for Liver Research and Diagnostics, Hyderabad
	• Centre for DNA Fingerprinting and Diagnostics, Hyderabad
Pancreatic progenitor cells	• National Institute of Nutrition, Hyderabad
	• National Centre for Cell Science, Pune
Cardiac stem cells	• Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram

Table 1 continued

Table 1 continued

Muscle stem cells	• Centre for Cellular and Molecular Biology, Hyderabad
Cancer stem cells	• Indian Institute of Science, Bangalore
CMC-DBT Centre for Stem Cell Research	• Christian Medical College, Vellore
Stem cell research facilities	• Postgraduate Institute of Medical Education and Research, Chandigarh
Clean room facilities for stem cell research	• Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow • KEM Hospital, Mumbai • L.V. Prasad Eye Institute, Hyderabad
Cord blood bank	• Reliance Life Sciences, Mumbai • Life Cell, Chennai

Source: Compiled by Author.

safety and efficacy before attempting clinical applications of stem cells. The basic requirements for clinical trial are: adequate infrastructure, i.e. Good Manufacturing Practices (GMP), clinical grade reagents, trained manpower, proper documentation, Standard Operating Procedures (SOPs), quality control, etc. In clinical application for most of the diseases, the basic issues such as which cells are best for which purpose, homing of cells, mechanisms of action, etc. involved in clinical trials are also not well known yet.

SCR in India: Emerging scenario

In India, several science agencies of the government are promoting SCR. Priority areas for research have been identified by means of thorough discussion in various fora on basic and applied research for specific diseases and various programmes have been supported on embryonic and adult stem cells. The major programmes include among others: establishment of hESC lines, use of limbal stem cells to repair corneal surface disorders caused by limbal stem cell deficiency; isolation, purification and characterization of haematopoitic, mesenchymal and liver stem cells; differentiation of stem cells into neural, cardiac, β cell lineages, etc. In addition, studies have been supported to explore the potential applications of adult stem cells in stroke, cardiac, pancreatic, spinal cord injury, use of lectins for haematopoitic stem cell preservation, etc. Apart from the government, some industry research organizations are also involved in SCR. For example, Reliance Life Science, Mumbai has characterized 10 stem cell lines including two neuronal cell lines, Dopamine producing neurons and neurons for patients of stroke. One cell line has been deposited in the National Centre for Cell Science (NCCS), Pune. Their research focus is on ESC; haematopoitic stem cells; treatment of leukaemia; sickle cell anaemia; and skin and tissue engineering.

Interaction between clinicians-basic scientists already exists in several centres in India such as the Christian Medical College (CMC), Vellore; L.V. Prasad Eye Institute (LVPEI), Hyderabad; National Institute of Mental Health and Neurosciences (NIMHANS), Bangalore; All India Institute of Medical Sciences (AIIMS), New Delhi; Sanjay Gandhi Post Gratuate Institute of Medical Sciences (SGPGIMS), Lucknow; Manipal Hospital, Bangalore, etc. Limbal stem cells are being routinely used at LVPEI, Hyderabad to repair corneal surface disorders caused by limbal stem cell deficiencies. More than 300 patients suffering from severe limbal stem cell deficiency have been treated using limbal stem cells At CMC, Vellore, a technology has been established for collection, isolation and purification of HSC for haploidentical haematopoietic stem cell transplantation. The first, haploidentical haematopoietic transplantation was carried out at CMC, Vellore in April 2003. NCCS, Pune and Indian Institute of Science (IISc.), Bangalore have shown that banana lectins may be used to preserve HSC and a patent has been filed for this finding. Phase I multi-centric clinical trial and a pilot study using bone marrow mononuclear cells have been initiated in the country on myocardial infarction and stroke, respectively.

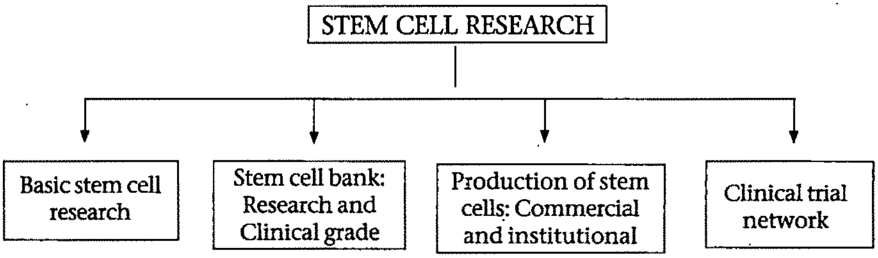
A 'CMC-DBT Centre for stem cell research' has been supported at CMC, Vellore. SCR facilities are also being created at the Post Graduate Institute of Medical Education & Research (PGIMER), Chandigarh. The training centre for embryonic and adult stem cells has been supported jointly at the National Centre for Biological Sciences (NCBS) and Jawaharlal Nehru Centre for Advanced Scientific Research (JNCSAR), Bangalore. Clean room facilities for SCR are being established at SGPGIMS, Lucknow; KEM Hospital, Mumbai; and LVPEI, Hyderabad. Dedicated short and long-term overseas fellowship programmes have been initiated by the Government of India for providing training to twenty five fellows every year in niche areas including stem cells. It has been decided to support both clinical and basic research on stem cells simultaneously. To consider the clinical trial proposals, four separate committees have been constituted: (i) Human Studies Committee for evaluation and guidance for clinical research particularly for the development of clinical research protocols; (ii) Ethical Committee for Stem Cell Research to ascertain rigid ethical guidelines being followed while conducting research on human beings; (iii) Task Force to evaluate basic research and also recommend the funding for clinical research based on the evaluation of the above committees; and (iv) Programme Advisory Committee to consider the proposals received for the Centre of Excellence. For clinical application of stem cells, the initial focus could be on the phase-I clinical trial in cardiology, stroke, orthopaedics, limb ischemic disease, bone marrow transplantation for leukemia, spinal cord injury, liver, etc. As the experience and success is gained, this may be expanded to other clinical applications also.

Would Stem Cell Bank be a Reality?

Thorough research is needed to understand exactly how stem cells work and how their potential can be harnessed for treatments of various diseases. Good quality of research materials are needed to carry out detailed basic research that may lead to clinical applications. A stem cell bank may be a useful repository for all types of stem cells, i.e. cord blood, adult and embryonic which may resolve the issue of standardization of cells/research materials as it is an important criteria for comparison and the reproducibility of results. The bank may hold stem cell lines derived originally from embryonic, foetal and adult tissues. This would also reduce the use of surplus embryos for the development of stem cell lines by individual teams. There is a need to develop genetically and biologically more diverse stem cell lines with better technologies in order to speed research for therapeutic purposes. To set up a stem cell bank it requires proper networking among hospitals for supply of cord blood and a public-private partnership model may work. Stem cells obtained from the bank may be used to examine and to better understand the process of all development, to learn how specific cell types and specific tissues and organs are formed. It may also be useful in enabling an understanding of the properties and behaviour of stem cells to determine their usefulness for future cell therapies; to understand what goes wrong in cells to cause various diseases. One may also study their ability to form different types of cells that can be used to restore or replace damaged tissue in patients with disease or injury; may compare hESC lines for their potential in tissue repair with adult stem cells; and confirm whether stem cells from adult tissues or umbilical cord blood are pluripotent as compared to hESCs.

Parameters for quality control procedure in the stem cell bank are: checking of chromosomal abnormalities, testing of infectious diseases such as HIV I&L, HTLV, HCV, HBS Ag, CMV ability of stem cells to undergo freeze-thawing processes, immune compatibility of the stem cells with patients potentially requiring the cells, presence of viruses within the stem cells that may cause disease, ability of the stem cells to give rise to the required adult cell types when required, and ability of the stem cell numbers to be increased to useful amounts. In India, some companies have started establishing the repositories of cord blood banking. Reliance Life Sciences, Mumbai has a repository of 3,000 cord blood samples. These samples have been processed and tested for infectious diseases and stored at 196^0C. Life Cell is a Chennai-based company and has a licence agreement and knowledge-sharing tie up with Cryo-Cell International, USA. They have a repository of 1,000 cord blood samples and are offering to preserve stem cells for 30 years.

Future Strategy for SCR


STEM CELL RESEARCH
Basic stem cell research
Stem cell bank: Research and Clinical grade
Production of stem cells: Commercial and institutional
Clinical trial network

In the country, the main features of a strategy for SCR include the promotion of both basic and translational research using adult and embryonic stem cells as well as other more readily available sources such as bone marrow, peripheral blood and umbilical cord blood cells. The strategy also includes the creation of good infrastructure to handle stem cells. Human Resource Development (HRD) is the most important component of the strategy as creation of a critical mass of stem cell researchers in the country is a priority. This will include extensive training programmes, close interactions between basic scientists and clinical researchers, international collaboration including personnel exchange programmes, annual conferences, workshops, etc. There is also a necessary focus on stem cell banks to resolve the issue of good quality research materials. Public-private partnership may be an ideal model for large-scale production of MSCs under cGMP conditions which will enable development of advanced technologies and products in this area.

Awareness must be created in industry which will be a stakeholder in the market scope of stem cell research. Once the process is standardized and the product is established, industry may take up further production/scale up for commercialization.

Global Regulations on SCR

Though SCR is one of the most exciting areas of the life science today, it has created lot of controversies and raised various ethical and moral issues on the use of embryonic/foetal stem cells in research. The

Table 2: Global Regulations of Human Embryonic SCR

Country	Policy
Australia	Approved SCR on human embryo isolated from supernumerary embryo after getting consent from the donors.
Canada	Assisted Human Reproductive Act allowing researchers to derive embryonic stem cell lines from left over embryos.
China	Human embryonic stem cells used for research purpose can only be derived from surplus IVF embryo, embryos created from fully-donated gametes and by nuclear transplantation.
France	France permitted research on embryo-derived cells in July 2004. French decree authorizing import of embryonic stem cells derived from supernumerary IVF embryos with the consent of the donors and research on the imported cells.
Germany	Prohibits the derivation and use of human embryonic stem cells from blastocysts.
India	Establishment of new hESC lines from spare, supernumerary embryos is permissible with prior approval of the Institutional Committee for Stem Cell Research and Therapy (IC-SCRT) and Institutional Ethics Committee (IEC) provided appropriate consent is obtained from the donor as per the draft guidelines.
Ireland	Prohibition of the creation of human embryos for research purposes and for the procurement of stem cells from human embryos by law.

Table 2 continued

Table 2 continued

Country	Policy
Singapore, Israel, Italy	Allow the creation of human embryos for research purpose with somatic cell nuclear transfer technique as well as use of supernumerary embryos for procurement of human embryonic stem cells.
South Korea	Guidelines set by the Ministry of Health and Welfare issued after the South Korean Parliament in January 2004 banned human cloning but left room for stem-cell research for curing diseases.
Spain, Sweden, Denmark, Finland Greece, The Netherlands	Allow the procurement of human embryonic stem cells from supernumerary embryos .
United Kingdom and Belgium	Allow the creation of human embryos for research purpose by *in-vitro* fertilization, with somatic cell nuclear transfer technique as well as use of supernumerary embryos for procurement of human embryonic stem cells.
United States	Allow surplus frozen embryos from *in vitro* fertilization clinics for SCR with the permission of donors

Source: Compiled by Author.

controversy is not because of its goals, but rather because of the means of obtaining cells. There is no controversy in the research involving stem cells derived from adult tissues and umbilical cord blood. The crux of the debate centres around derivation of embryonic stem cells which require the destruction of an embryo.

Legislation governing hESC research varies from country to country. Some countries like India, Israel, Singapore, Sweden, Australia, United Kingdom and other European countries have relatively liberal and research-favourable regulatory policies, while others are still struggling to draft regulatory policies. Draft guidelines for SCR in India have been formulated jointly by the Department of Biotechnology, Ministry of Science and Technology and Indian Council of Medical Research. The same is currently being placed for public debate.

Conclusion

To explore the possibilities of clinical applications using stem cells, thorough basic research on all types of stem cells i.e. embryonic, adult and tissue is essential. National agencies are pro-active in supporting and promoting this area. However, there are many challenges in current stem cell research such as non-availability of human resources of adequate expertise; very few indigenous hESC lines generated; inter disciplinary structure is yet to be created; enabling regulatory mechanisms is still evolving, etc. There is an enhanced awareness among the scientists and clinicians in the country about SCR and the process has gained momentum.

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Regulation of Biotechnology Goods and Issues for Developing Countries before the Multilateral Trading System

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Abstract: Modern biotechnology has the potential to provide a major impetus to global food security and trade. Therefore, this field is of special concern and interest to developing countries. On the other hand, much of its implications remain unknown, especially the possible human and animal health impacts as well as the impacts on receiving environments. The concern is heightened in developing countries, which are custodians of rich biodiversity. Further, international rules governing States' freedom to regulate biotechnology products in their territories are fraught with uncertainty, due to the lack of clarity regarding the applicable multilateral trading system (MTS) rules, and their relationship with the multilateral environmental agreements (MEAs) dealing with biosafety. This paper sets out to provide a legal analysis of the prevailing uncertainty in the international rules, and then taking the case of Sri Lanka submits that the prevailing impasse works particularly against developing countries. It concludes by highlighting some courses of action developing countries may take, both at the national and international level, to safeguard their biodiversity heritage.

Keywords: Biodiversity, Biotechnology, Developing countries, LMOs, Sri Lanka, WTO

Introduction

The regulation of product characteristics and their related processes and production methods is an issue of critical importance for products that may be traded internationally. It is also one that is of particular concern to developing countries pursuing export-led economic growth. The demands placed by the health, safety, environmental and other

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requirements and standards in export markets with respect to products that are of export interest to the developing countries concerned, may represent a significant non-tariff barrier to the trade of those products. This is reflected in the various compromises and concessions reached between the developed and developing countries in the course of the Uruguay Round negotiations of the General Agreement on Tariffs and Trade (GATT), which culminated in the coming into being of the multilateral trading system (MTS) under the WTO Agreement, ten years ago. It has also been at the forefront of subsequent negotiations within the WTO, including in relation to the Doha Development Agenda.

The importance of addressing the real concerns of the developing countries in this area is not disputed. However, developing countries' activism in relation to the requirements and standards in their *export* markets has not been matched by any degree of activism for securing special treatment under the MTS for regulations or standards that they *themselves* may seek to adopt. As a result, developing countries are at a considerable disadvantage in being subjected to the same disciplines as are applicable to the developed countries. This is illustrated particularly vividly in the case of uncertainties surrounding the regulation of internationally-traded products of modern biotechnology.

Modern biotechnology has been a rapidly developing frontier of science, holding great promise for the future of humankind.[1] In the area of agriculture, living modified organisms[2] (LMOs) have the potential to provide a major impetus to global food security and nutrition, trade in agricultural products, as well as an improved environment. As such, the utilization of this science is of especial concern and interest to the developing countries. At the same time, much of the implications of the evolving science remain unknown, including possible human and animal health impacts and, especially, the potential environmental impacts when LMOs are introduced into the environment to live or grow, such as fish or seeds.[3] The last concern, particularly acute in the nations of the South Asia region, which are custodians of rich biodiversity, forms the special focus of the present paper. However, the discussion is also applicable to the potential human and animal health impacts of LMOs in food or feed, or processed products.

States have to institute adequate regulatory systems in order to ensure that LMOs introduced into the environment do not result in harming their biodiversity. These would include border measures to regulate the importation of LMOs, as well as measures relating to their handling and use within the territory. This has implications for the international trade in those products, and thereby for the MTS. However, States' freedom of action to regulate LMOs under the MTS is beset with uncertainty. The causes of this uncertainty are twofold. The first relates to the applicability of the multilateral trade agreements of the WTO to the regulation of LMOs. The second source of uncertainty relates to the relationship between the MTS and the applicable multilateral environmental agreements (MEAs). The following two sections discuss each of these in turn.

Applicability of Multilateral Trade Agreements to the Regulation of LMOs

Within the framework of the WTO Agreement, there are several different regimes that may potentially apply to the regulation of LMOs, with different requirements attaching to each. Two multilateral trade agreements that seem to be directly relevant are the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) and the Agreement on Technical Barriers to Trade (TBT Agreement). The SPS Agreement will be applicable to Members' sanitary and phytosanitary measures which may, directly or indirectly, affect international trade.[4] The Agreement defines a "sanitary or phytosanitary measure" as any measure applied,

(a) to protect animal or plant life or health within the territory of the Member from risks arising from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms;

(b) to protect human or animal life or health within the territory of the Member from risks arising from additives, contaminants, toxins or disease-causing organisms in foods, beverages or feedstuffs;

(c) to protect human life or health within the territory of the Member from risks arising from diseases carried by animals, plants or products thereof, or from the entry, establishment or spread of pests; or

(d) to prevent or limit other damage within the territory of the Member from the entry, establishment or spread of pests.[5]

Whether measures regulating LMOs intended for introduction into the environment would be within the purview of the SPS Agreement accordingly depends on whether those LMOs can be treated as "pests, diseases, disease-carrying organisms or disease-causing organisms."[6] It is not clear whether either of these expressions is apt to accommodate LMOs. Furthermore, each of them carries a connotation of causing harm or damage, which in the case of LMOs has yet to be positively established. Therefore, at the threshold level there is a doubt as to whether the SPS Agreement would apply. If the SPS Agreement does not apply to LMOs, it is very likely that the TBT Agreement would then apply. This Agreement applies to all measures outside the purview of the SPS Agreement, which set out product characteristics or their related processes and production methods. In terms of this definition, measures dealing with LMOs could be regarded as measures dealing with a product characteristic or a process or production method, thus falling within the scope of the Agreement.

The question of which agreement would apply is important because each imposes distinct requirements on Members. The SPS Agreement imposes stringent requirements. As a general rule, any SPS measure must be "based on scientific principles," and more particularly, should be based on a risk assessment.[7] The WTO Appellate Body has strictly upheld these requirements in the *EC-Hormones* and *Australia-Salmon* cases (see Table 1 for a list of such cases).[8] Although the SPS Agreement does not in terms restrict the right of a Member to determine its appropriate level of sanitary or phytosanitary protection, given the scientific uncertainties surrounding the case of LMOs, and the limited capacities of developing countries to undertake a risk assessment to international criteria, in practice it

Table 1: List of Select Cases at WTO

Respondent	Subject	Case Reference
Australia	Measures Affecting Importation of Salmon	Australia – Salmon (Case No. WT/DS18)
European Communities	Measures Affecting Asbestos and Products Containing Asbestos	EC – Asbestos (Case No. WT/DS135/AB/R)
European Communities	Measures Concerning Meat and Meat Products (Hormones)	EC – Hormones (US) (Case No. WT/DS26)
European Communities	Measures Concerning Meat and Meat Products (Hormones)	EC – Hormones (Canada) (Case No. WT/DS48)
Japan	Measures Affecting Agricultural Products	Japan – Agricultural Products II (Case No. WT/DS76)
United States	Standards for Reformulated and Conventional Gasoline	US – Gasoline (Case No. WT/DS2/R)

would be very difficult for a developing country to regulate trade in LMOs under the SPS Agreement.

In an exceptional case, an SPS measure may be adopted in the face of insufficient scientific evidence.[9] While this could form the basis to regulate LMOs, the scope of this right is limited by a number of conditions. For example, the measure has to be provisional only. It should be based on "available pertinent information, including that from the relevant international organizations as well as from sanitary or phytosanitary measures applied by other Members," and the Member must seek to obtain the necessary information for a more objective risk assessment and review the measure "within a reasonable period of time." It is to be noted that these prescriptions are inherently vague and admit of diverging interpretations, which is a point that will be returned to in the concluding section of this paper.

The TBT Agreement permits members more latitude in the adoption of measures that are covered by it. For example, scientific evidence is only one reason that may be used to justify a technical regulation, other justifications include related processing technology or intended end-uses of products.[10] However, the TBT Agreement imposes the requirement that measures should not create "unnecessary obstacles to international trade," and that they do not discriminate between "like" products of national or international origin.[11] In the case of the former requirement, GATT and WTO jurisprudence interpreting a similar provision in the GATT 1947/1994 have applied a strict standard for any measure that sought to meet this threshold.[12] In the case of the latter, there is uncertainty whether products containing, or derived from,[13] LMOs are "like" the comparable product that does not contain, or is not derived from, such organisms. Therefore, significant scope for diverging views exists under the TBT Agreement.

In addition to the SPS and TBT Agreements, the GATT 1994 may also apply. Article XX(b) permits contracting parties to adopt measures that may be inconsistent with the other provisions of the GATT, if they are "necessary to protect human, animal or plant life or health," and Article XX(g) permits the same freedom with respect to measures "relating to the conservation of exhaustible natural resources" that are made effective in conjunction with restrictions on domestic production or consumption. However, such measures should satisfy the requirements of the opening paragraph of Article XX (the chapeau), which requires that they should not result in "arbitrary or unjustifiable discrimination between countries where the same conditions prevail," nor in a "disguised restriction on international trade." As Articles XX(b) and (g) are exceptions, to a contracting party's obligations under the GATT, any measure that seeks to rely on them has to discharge a high burden of proof.[14] This is likely to prove a steep hurdle for developing countries trying to regulate trade in LMOs.

Relationship between the MTS and Applicable MEAs

The second source of uncertainty flows from the relationship between the Multilateral Trading System (MTS) and Multilateral Environmental Agreements (MEAs) dealing with the regulation of Living Modified Organisms (LMOs). This is an aspect of the larger issue of the relationship between the MTS on the one hand, and on the other, MEAs that provide for the taking of trade measures for environmental protection purposes. The issue arises because the MTS and MEA regimes may impose conflicting obligations on States that are party to both. A typical example is where an MEA permits trade in a certain product or products to take place between parties to the MEA, while restricting trade in the same product or products between parties and non-parties (WTO 2004:36). For example, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, an MEA, bans the export or import of hazardous or other wastes taking place with non-parties to the Convention. However, under the WTO Agreement this would be a violation of the principle of non-discrimination between like products, contained in Article I of the GATT 1994.[15]

The question arises whether in these circumstances, the MTS regime should prevail over the MEA system, or, whether, the MEA regime should prevail over the MTS or, alternatively, whether some middle ground should be charted between the two regimes. The principles of international law on treaty interpretation provide some guidance on this matter. According to the 1969 Vienna Convention on the Law of Treaties, where there is an earlier treaty and a later treaty applicable to the same matter, as between States that are parties to *both* treaties, the earlier treaty applies only to the extent that its provisions are compatible with those of the later treaty.[16] In other words, in the event of inconsistency between the two treaties and the absence of contrary language in the later treaty, the provisions of the later treaty will prevail. However, it is provided that as between a State that is party to both treaties and a State that is party to only *one* of the treaties, the treaty to which *both States* are parties governs their mutual rights and obligations.

In the context of regulating LMOs, a potential conflict with the MTS is posed by the key MEA in this area, namely, the Cartagena Protocol on Biosafety of 2000 adopted under the 1992 Convention on Biological Diversity. The Protocol establishes a framework to regulate the transboundary movement, transit, handling and use of all LMOs[17] that may have adverse effects on the conservation and sustainable use of biological diversity or on human health. Like in the SPS Agreement, the Protocol includes a risk assessment requirement, which is to be undertaken in the case of the Protocol before a Party[18] decides whether, and on what conditions, it allows LMOs to be imported into its territory. However, there is a significant divergence between the Protocol and the SPS Agreement with respect to the party on whom the onus of undertaking risk assessment is placed (WTO and WHO 2002: 132). As discussed above, the SPS Agreement places this onus on the Member adopting the measure, whereas the Protocol provides that the *exporter* may be required to carry out the risk assessment, or alternatively, to bear its cost.

There is another important difference between the two regimes in the measures that may be adopted by a State where there is insufficient scientific information and knowledge regarding potential adverse impacts. This is due to the fact that the Protocol explicitly adopts the "precautionary approach" principle set out in Principle 15 of the 1992 Rio Declaration on Environment and Development.[19] Accordingly, under the Protocol, in the face of scientific uncertainty a Party may, out of precaution, ban the import of LMOs into its territory. Although the Protocol contemplates this as a last resort, nonetheless it leaves a Party with an untrammelled right to invoke it as felt necessary.[20] It has already been mentioned that in the case of the SPS Agreement, such a measure would have to meet with a number of conditions laid down in that Agreement, which have been strictly construed by the dispute settlement organs.[21]

Similar conflicts are possible between the Cartagena Protocol and the TBT Agreement and Articles XX(b) and (g) of GATT. In the case of the TBT Agreement, the special regime for LMOs provided in the Cartagena Protocol may be a violation of the principle of non-discrimination between "like" products. It may also be challenged as creating an "unnecessary obstacle to international trade." In the case of Article XX(b) of GATT, the Protocol regime may be challenged on the basis of whether it is "necessary" for the protection of "human, animal or plant life or health."[22] While Article XX(g) of GATT allows more latitude in that a measure falling under that paragraph only needs to be "related to" the conservation objective, it is possible that there could be a divergence of opinion as to what constitutes "exhaustible natural resources" in a given case.

While the rules of the Vienna Convention on the Law of Treaties, recounted above, may provide the juridical solution to the potential conflict between the MTS and Cartagena Protocol regimes in the matter of regulating trade in LMOs, however, it is very unsatisfactory where a fundamental issue – the relationship between trade and environment - has to be resolved on the basis of a chronological accident of when the respective regimes came into being.[23] Furthermore, the juridical solution gives rise to immense practical difficulties when faced with non-contiguous memberships in the respective treaty regimes. One treaty would define the rights and obligations of a State in its dealings with some States while another or others would apply in respect of the same subject matter in dealings with other States.

Attempts to Resolve the Impasse Surrounding the Regulation of LMOs

The foregoing discussion highlights some of the significant uncertainties that prevail in the international regimes bearing on the regulation of LMOs. It also illustrates the difficulties in complying with the potentially applicable multilateral trade agreements in the face of the scientific uncertainty that surrounds the potential adverse impacts of LMOs. In the run up to the Seattle Ministerial Conference in 1999, proposals were made by Canada and Japan to have this issue addressed in the WTO. It was proposed to set up a working group to study the relationship of the multilateral trade agreements and modern biotechnology products and to evaluate the need for further action. However, this was vetoed by the majority of Members who saw it as posing a threat to the adoption of a strong biosafety protocol in the negotiations then underway under the Convention on Biological Diversity, on what was to become the Cartagena Biosafety Protocol (Khor 1999).[24]

While the timing of the proposal may have, therefore, been inappropriate, it is unfortunate that since the adoption of the

Cartagena Protocol no attempt has been made to revisit the issue within the WTO. As a result, the ambiguities in relation to the applicable MTS disciplines continue to await a satisfactory resolution.

There have been some positive steps within the WTO with respect to addressing the relationship between the MTS and MEAs in general that contain trade measures. The WTO Ministers meeting at the Fourth WTO Ministerial Conference in Doha, Qatar on 9-13 November 2001 undertook to commence negotiations on this relationship "with a view to enhancing the mutual supportiveness of trade and environment".[25] However, the negotiations have been confined in scope to the applicability of WTO rules among WTO Members who *are parties to the MEA in question.*[26] As a result, the negotiations are unlikely to resolve the potential conflict between the trade and environmental regimes' bearings on the regulation of LMOs, for the very reason that many of the world's leading exporters of LMOs – the USA, Canada, Argentina, Chile and Uruguay – are not parties to the Cartagena Biosafety Protocol.

Thus, neither of the two sources of uncertainty in relation to the regulation of LMOs, that have been referred to in this paper, are likely to be addressed at negotiations in the WTO. This situation constrains members of the MTS from adopting effective regulatory systems for LMOs based on the precautionary principle. This is illustrated in Sri Lanka's attempt in 2001 to ban the trade in foodstuffs containing LMOs, which is discussed next.

Sri Lanka's Ban on Trade in Foodstuffs Containing LMOs

On 26 June 2001 the Minister of Health proclaimed a set of regulations under the Food Act titled, the Genetically Modified Foods (Provisional) Regulations, No. 1 of 2001 (Sri Lanka 2001a). Regulation 2 of the Regulations provided that

> "with effect from the date of operation of these regulations and subject to the other provisions of the Act, no person shall import, manufacture for commercial purposes, transport, store, distribute, sell or offer for sale any food, raw or processed or any ingredient of food or food additive that has been subjected to any genetic modification using DNA recombinant technology or any food that contains one or more ingredient or additive that has been subjected to genetic modification."

Regulation 3 went on to provide that in the case of 21 food items listed in the Schedule to the Regulations, no person may import any of those food items without obtaining a certificate from a designated authority in the country of export to the effect that such item does not contain any material or ingredient that has been subjected to genetic modification.[27] The Regulations were to come into operation on 1 September 2001.

The impending operation of the Regulations was notified to the SPS Committee on 19 July 2001 in terms of the SPS Agreement's prior notification requirements.[28] However, on 29 August 2001 the Minister of Health issued a notification deferring indefinitely the coming into force of the Regulations, which was to originally take place on 1 September (Sri Lanka 2001b). Ostensibly, this was to give effect to the SPS Agreement's recommended time of at least sixty days' notice prior to the coming into force of a measure within the scope of that Agreement. However, even after the lapse of the requisite period of notice, the Regulations were never subsequently brought into operation.

The fact is that the Regulations had drawn fire from the USA and Australia, whose trade would have been directly affected by the Regulations. The USA threatened Sri Lanka with sanctions under the WTO if the measures were brought into force. The Sri Lankan government bowed to the pressure from two important trading partners and the Regulations were abandoned. Since this failed attempt, LMO-containing food and feed, and LMOs intended for processing or for introduction into the environment, have been freely entering the country and have been used without any regulatory framework to guard against potential adverse consequences.

The case of the abortive Sri Lankan regulation highlights the difficulties that a developing country faces under the MTS in attempting to take proactive measures against any potential adverse effects of LMOs. It is submitted that the Sri Lankan measure, while extreme in its outright ban of certain categories of LMOs, was nonetheless within the rights of a Party under the Cartagena Protocol on Biosafety.[29] However, the exercise of these rights is constrained by the uncertainty, discussed in this paper, surrounding the relationship between the Cartagena Protocol and MTS regimes. This is compounded by doubts regarding which of the two multilateral trade agreements would be applicable to this issue, as well as the ambiguous wording of the potentially applicable trade rules.

This uncertainty surrounding the applicable legal rules enables the economically powerful LMO exporter States to foist the agenda of their biotechnology industry lobbies over the concerns of less powerful developing countries to regulate LMOs for potential health and biodiversity impacts. As the Sri Lankan regulation shows, the mere threat of legal proceedings under the WTO can sometimes cow a State into submission as it lacks the resources to engage in expensive proceedings to vindicate its measures. When such developing countries are custodians of rich biodiversity, they have the most to lose from this prevailing state of affairs under the MTS regime. The failure to institute adequate regulatory systems for LMOs, based on precautionary norms, in such countries can have potentially far reaching consequences on their biodiversity endowment. Therefore, it is these countries that must take the initiative to have a satisfactory resolution of the prevailing uncertainties under the MTS.

Conclusion

On previous occasions, developing countries have successfully united to bring common concerns to the agenda of MTS negotiations.[30] The present issue strongly merits a similar concerted response by all interested developing countries as this alone can overcome the vested interests of the biotechnology industry in the prevailing MTS regime status quo. Apart from seeking a resolution of the present uncertainties hindering effective LMO regulation, developing countries should also canvass for special and differential treatment under applicable MTS rules in adopting their own regulatory measures for LMOs. As mentioned in other parts of this paper, this aspect has been neglected by the developing countries in the debate on product standards, and as a result developing countries adopting their own regulatory measures have to meet the high thresholds set by potentially applicable multilateral trade agreements.

Even within the context of the present MTS, there are several areas where developing countries can benefit from a collaborative approach. One such area is in the pooling of scientific research on the effects of LMOs. It has already been mentioned that many developing countries may find it difficult to conform to the SPS Agreement's requirements in respect of scientific risk assessment. Collaboration with other developing countries, in particular within the regional context, in order to carry out the necessary scientific testing, would be mutually beneficial. Another area for collaboration lies in participating in the work of international standard-setting bodies that have a bearing on LMOs.[31] Through concerted pressure developing countries would be able to ensure that whichever international standards as are adopted make suitable provision for the special concerns and circumstances of the developing countries.

In conclusion, it must be stressed that developing country governments should take urgent measures for safeguard *now*, to avoid potentially irreversible impacts on biodiversity from the use of LMOs. The Sri Lankan case discussed in the last section underlines how a political leadership can find it much easier to simply back down and bow to interested international pressure, when there is no countervailing domestic pressure demanding regulation. Therefore, there is a need to mobilize the widest possible popular consensus in favour of instituting effective measures to regulate LMOs. Such popular support can be translated into effective pressure on governments to steadfastly pursue their regulatory measures in the future. In this respect, civil society and non-government organizations in these countries have a key role to play in both raising public awareness about LMOs, as well as directly pressurizing governments into action.

Endnotes

[1] Selective breeding and cross-fertilization of plants and animals goes back millennia and are practices of traditional biotechnology. However, modern biotechnology encompasses the ability to extract and transfer strands of DNA or entire genes from one species to an entirely different species, by manipulating the genetic structure of individual living cells. For a technical definition of "modern biotechnology," see the Cartagena Protocol on Biosafety, Article 3.

[2] Adopting the terminology of the Cartagena Protocol on Biosafety, "living modified organisms" are biological entities that can transfer or replicate genetic material (for example, seeds, fish, animals, as well as sterile organisms, viruses and viroids), which possess a novel combination of genetic material obtained through the use of modern biotechnology (see Article 3 of the Protocol). The Cartagena Protocol is discussed in the third section of this paper.

[3] For an overview of the potential benefits and dangers of LMOs, see CBD and UNEP 2003.

[4] SPS Agreement, Article 1.1. The term "Member" is used in this paper to denote a Member of the WTO.

[5] Per Annex A of the SPS Agreement.

[6] In the case of LMOs intended for use as food or feed, or for processing, whether they would amount to "additives, contaminants, toxins or disease-causing organisms in foods, beverages or feedstuffs" constitute additional grounds for coming under the SPS Agreement.

[7] See SPS Agreement, Articles 2.2 and 5.1.

[8] European Communities – Measures Concerning Meat and Meat Products (Hormones) Case No. WT/DS26 (EC – Hormones (US)), European Communities–Measures Concerning Meat and Meat Products (Hormones) Case No. WT/DS48 (EC – Hormones (Canada)), Australia – Measures Affecting Importation of Salmon Case No. WT/DS18 (Australia – Salmon). From http://www.wto.org.

[9] SPS Agreement, Article 5.7.

[10] See Article 2.2 of the TBT Agreement.

[11] See Articles 2.1, 2.2 and Annex 3 of the TBT Agreement.

[12] See the discussion of GATT Article XX(b), below.

[13] For example cooking oil made from genetically modified corn or soybeans.

[14] See paragraph 6.20 of the Panel Report and p. 22 of the Appellate Body Report in United States – Standards for Reformulated and Conventional Gasoline Case No. WT/DS2/R (US – Gasoline). From http://www.wto.org.

[15] See WTO 2003 for further examples of MEAs dealing with trade measures.

[16] Unless the later treaty specifies that it is subject to, or that it is not to be considered as incompatible with, the earlier treaty: Article 30 of the Vienna Convention.

[17] However, LMOs that are pharmaceuticals for humans addressed by other relevant international agreements or organizations are excluded from the scope of the Protocol (Article 5 of the Protocol).

[18] The term "Party" is used to denote a State that is a party to the Cartagena Protocol.

[19] Principle 15 provides that, "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

[20] However, a Party should be prepared to review its decision if required to do so by an affected party (Article 12).

[21] See the Appellate Body decision in Japan – Measures Affecting Agricultural Products Case No. WT/DS76 (Japan – Agricultural Products II). From http://www.wto.org.

[22] The application of the "necessary" test has given rise to a substantial jurisprudence. See paragraphs 164-175 of the Appellate Body Report in European Communities – Measures Affecting Asbestos and Products Containing Asbestos Case No. WT/DS135/AB/R (EC – Asbestos), which includes a review of the existing jurisprudence. From http://www.wto.org.

[23] In the case of the relationship between the WTO Agreement and the later Cartagena Protocol, the application of the Vienna Convention rules is further complicated by the fact that the Cartagena Protocol provides that it is not to be treated as overriding, nor as subordinate to, existing international agreements (see the Preamble).

[24] The proposal had been supported by USA, Canada, Chile, Argentina and Uruguay, the leading exporters of genetically engineered agricultural products.

[25] Ministerial Declaration adopted on 14 November 2001 (Doha Declaration), paragraph 31.

[26] Doha Declaration, paragraph 31(i).

[27] The food items listed included soya, corn, tomato and their processed variants, cheese and microbiological starter cultures used in food.

[28] Thus, implicitly accepting that the SPS Agreement applies to the measure. It has been argued in the present paper that this question is not at all free from ambiguity.

[29] Sri Lanka signed the Cartagena Protocol on 24 May 2000. The Protocol came into force for Sri Lanka on 26 July 2004, 90 days after the date of deposit of its instrument of ratification in terms of Article 37 of the Protocol.

[30] An example is the group of developing countries known as the G-20 formed in the run up to the 2003 Fifth WTO Ministerial Conference at Cancun, to canvass common interests in the agriculture negotiations.

[31] The principal bodies are, in the area of food safety and consumer health the Codex Alimentarius Commission, in the area of animal health the World Organization for Animal Health (OIE) and in the area of protection of plant health from pests the International Plant Protection Convention (IPPC).

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Advances in Agriculture Biotechnology

Drugs from plants and animal genes

Bacteria, yeast, and mammalian cell cultures are routinely used for large-scale commercial production of biopharmaceuticals, but these systems are costly and lack flexibility for scaling up production. Typical unit production costs range from US$100–1,000 per gram of purified protein product, depending on the product, volume, and production system. Capital investment is in the order of several hundred million dollars for a large capacity facility.

The construction and validation of GMP compliant facilities requires long lead times, typically three to five years, which creates challenges in matching capacity to demand. As a result, companies must make manufacturing choices and a substantial upfront investment in capacity while their products are still in the test phases. The uncertainty of regulatory approval, and the difficulties in predicting market demand impose a significant business and financial risk. For drug developers, investing large amounts of capital on a drug that is awaiting approval, is an expensive and very risky prospect; however, having a drug that is approved without a reliable supply of product can have equally dire consequences.

Transgenic production holds tremendous promise for dealing with the cost, capacity and scale-up limitations faced by traditional systems. Trans-genics can substantially reduce capital investment and lower production costs through economies of scale and more-flexible scale-up. Such advantages could enable the commercialization of proteins that would otherwise be impractical due to cost or capacity constraints, and provide scope for pricing flexibility that could be passed on to patients and health care systems. These benefits could allow companies to expand into new markets, such as follow-on biologics, where price is a barrier to entry.

The world's first medicine derived from a genetically engineered animal has been recommended for approval by a panel of European experts, following a re-examination of the evidence. The European Medicines Agency had initially rejected ATryn, an anti-clotting agent for use by people with a rare inherited disease, which is made from the milk of transgenic goats. But the agency's Committee for Medicinal Products for Human Use (CHMP) said that it had now changed its mind and supported the drug's use in patients with congenital antithrombin deficiency undergoing surgery, to prevent deep-vein thrombosis.

Focus on rice for higher yields

Scientists have announced plans to radically boost rice yields, warning that unless production increases millions of people could fall back into poverty. Traditional methods of increasing rice production such as crossing different varieties have been pushed to the limits of what is scientifically possible. But now that researchers have sequenced entire genetic code for rice more advanced approaches could become available. Key to the strategy discussed at the workshop is a difference in the way that rice and other plants convert sunlight and carbon dioxide into sugar for growth, a process called photosynthesis. Rice photosynthesis is less efficient than that of some other plants such as maize that use an extra chemical process for capturing carbon dioxide. The researchers at IRRI say it should be possible to transfer this process to rice by inserting genes from maize or from wild relatives of rice that also use it. The project is ambitious. The specialists say it would take about four years to determine whether the technique is feasible and another 10-15 years until the first improved varieties are available.

Similar efforts are also on at the Department of Molecular Biology and Genetics at Cornell University for improving the rice yields by adding a molecule responsible for photosynthesis. A highly specialized molecule that responds to light, called a photoreceptor, provides a new plant architecture and increases grain yield. Translucent white grains with a great aroma are the well-known characteristics of Basmati rice that renders this rice so attractive for global agricultural markets. However, yields are reduced by other traits of Basmati rice. For example, a tall stature and a weak stem are among the traits that trigger low yields. Yet, genetic engineering could solve this issue. This is exactly what a research group at Cornell did.

Apart from efforts at IRRI, recently, researchers of the Department of Molecular Biology and Genetics at Cornell University published their work in the journal *Planta*. They reported on how they were able to increase the production of *Arabidopsis thaliana* PHYTOCHROME A (PHYA), which led to an increase in grain yield in a rice variety called Pusa Basmati-1 rice. The PHYA gene that they studied encodes a photoreceptor belonging to the phytochromes, a family of molecules absorbing light in the range of red to far-red. When light hits the PHYA photoreceptor, it induces a structural change in PHYA, which triggers an intercellular signal called a signal-transduction.

The team generated transgenic Pusa Basmati-1 rice seedlings containing the Phytochrome A gene - the photoreceptor - of Arabidopsis thaliana, a plant common in research. The main effect of the increase in the production PHYA has been observed by the research group in several experiments. For example, in experiments with tomatoes, a phenomenon called dwarfing occurred, where the overall stature of the tomato plant was reduced. In addition, by increasing the production of PHYA, the adult tomato plants grew bushier and increased their branching.

Although the complete mode of action of PHYA is not understood, what is known is that this type of photoreceptor belongs to the phytochromes, a family of molecules absorbing light in the range of red to far-red. When light hits the PHYA photoreceptor, it induces a structural change in PHYA, which triggers an intercellular signal called a signal-transduction. The research group believe that if they are able to extend their observations to other rice varieties this could provide high yielding, semi-dwarf plants that can be used as donors in breeding programmes.

Next generations' transgenic technology for GM crops

Researchers at the National Research Centre on Plant Biotechnology (NRCPB) of Indian Agricultural Research Institute (IARI) have developed next generation transgenic technology for GM plants. In their approach, plants can be genetically modified through chloroplast transformation instead of the traditional nuclear method – as in the case of present day biotech crops such as soybean, cotton, canola and maize — for not just high yield but also with high level of protection against insect pests and significant saving on resources. Potato, tomato and agriculturally important crop plants such as carrot, cotton, soybean and oil seed mustard have been successfully modified this way to keep common infectious affiliations at bay. Researchers term their innovation as transplastomic plants.

Most importantly, this technique, called chloroplast genetic engineering, opens new opportunities for developing low-cost drugs and vaccines from transplastomic plants such as tobacco and tomato. Monsanto and ICGEB scientists have already demonstrated in tobacco plants how genetic engineering could potentially be used to produce vaccines and antibodies for fighting diseases such as cholera.

Genetic engineering of plants has tremendous potential to create crops with new metabolic capabilities, like the ability to accumulate pharmaceuticals or other high-value specialty materials, says KC Bansal, leading the research foray at NRCPB. The new technology could be used to develop fruit and vegetables that could help immunise against certain diseases. While several biotech crops with many desirable traits have already reached the market, and many more are in the pipeline, these are the outcome of nuclear transgenic technology. This is associated with certain drawbacks such as gene silencing, low level of gene expression, and most importantly, uncontrolled spread of the transgene via pollen to the neighbouring wild relatives.

Transplastomic plants would have a future only if they are demonstrated to be economically beneficial and have agronomically useful traits. With eight Indian states recently joining hands to collaborate with agricultural universities to come up with indigenous GM alternatives in the wake of Mahyco-Monsanto's exorbitant prices for GM crop seeds, the research efforts of biotechnologists need to be given an impetus to bring the technology from the confines of the laboratory into the agricultural landscape.

Uproar over diarrhea treatment grown in transgenic

In Peru a research experiment is under investigation for having tested two anti-diarrheal proteins from genetically modified (GM) rice on babies hospitalized in Peru with serious diarrhea attacks. Out of 140 babies, those given the proteins added to a standard rehydration solution recovered faster; the average recovery time was 3.67 days versus 5.21 days. Diarrhea is the second leading cause of death among children under five in Peru. The experimental proteins administered were made by a U.S. biotechnology company, Ventria Biosciences, which is also testing them on elderly patients in the U.S. International Academy of Life Sciences at Germany hailed the research a nonprofit Peruvian Medical Association has complained to authorities that the hospital tests endangered the babies involved, and were illegal.

Biotech to address metalic contamination

Heavy metal pollution is a big problem worldwide. Even essential metals such as zinc are toxic for all organisms when present in excess. However, some plants are able to grow in metal contaminated soils. These metal tolerant plants are important to scientists, as they can be used in bioremediation, the cleaning up of heavy metal pollution. How these plants can tolerate in heavy metal access, however, is still not understood. Research teams from institutes in France and Belgium have discovered one more clue to the hardiness of metal-tolerant plants.

Researchers screened an *A. halleri* cDNA library expressed in yeast that was grown in medium containing zinc. The screening revealed four cDNAs that encode plant defensins (PDF), a group of small proteins widely distributed in all living organisms. Defensins are known for their involvement in the plant immune system, inhibiting the growth of fungal pathogens. However, these proteins were previously unknown to play any role in metal physiology.

Researchers found that the gene induced zinc tolerance in yeast, but not cadmium tolerance. When they transferred the defensin genes to *Arabidopsis thaliana*, they found that transgenic plants were more tolerant to zinc than wild-type plants, but had not increased tolerance to cadmium, copper, cobalt, iron, or sodium. These results open up new horizons for the investigation of defensin mechanisms of action, both with respect to fungal growth inhibition and metal physiology in plants.

Chinese scientists develop salt tolerant grass

Scientists in China have developed a salt-tolerant form of grass that they say could be used to help bring millions of hectares of degraded land back into production. The team at the Beijing Research Center of Agro-Biotechnology published their findings in the *African Journal of Biotechnology*. The researchers genetically modified tall fescue grass (Festuca arundinacea) by inserting a gene from a relative of mustard called Arabidopsis thaliana. The modified plants had "remarkable salt tolerance", all growing better than non-modified plants under conditions of high salt stress, say the researchers. Tall fescue is grown widely in Africa, China and South America as turf and as a forage crop for grazing animals, but soil salinity is becoming increasingly problematic in many areas. This improved grass has the potential to benefit livestock operations that depend on sustainable forage production.

Israel to develop salinity resistance

Imagine what it would mean for the world hunger problem if farmers could grow wheat and other crops on land considered unsuitable for agriculture. That day may be coming soon, after Israeli researchers from the Institute of Evolution, University of Haifa, have succeeded in isolating a gene that withstands salinity. The research will contribute to a significant increase in the amount of arable land available for agriculture.

Of the earth's 57 million square miles of land, approximately 12 million square miles are arable - meaning land that can be used for growing crops. However, arable land is being lost at the rate of over ten million hectares per year. This research will make it possible to grow plants, including crops, in saline earth, a development that will contribute in the future to a true revolution in saline agriculture throughout the world.

Saline agriculture is the production of crops on land that is affected by salt. Too much salt in soil or in irrigation water will inhibit the growth of most crops, or may even kill them. Saline soils are found in arid lands, in coastal deserts, and where arable land has been ruined by poor farming practices. Modern methods of irrigation and fertilization of crops has caused much of the arable lands around the world to become saline. This is especially true in drylands because of the high rate of evaporation, which leaves the salt behind. More and more farmers are forced to plant crops on marginal lands and to use soil that was once arable but now has a high saline content.

In the current study, Eurotium herbariorum, a common fungal species, was isolated from the lake. The researchers isolated and sequenced the HOG gene that is responsible, in concert with other genes, for the fungus' ability to defend itself from the salinity of the Dead Sea. The gene was introduced into 'saccharomyces cerevisiae' - better known as baker's yeast - and the team observed that resultant transgenic yeast was able to tolerate more salt than normal, especially in resisting large temperature changes. The researchers found that in comparison to yeast that was not genetically engineered, the yeast that had been genetically transformed by the insertion of the HOG gene was more durable in saline or highly oxidative environments and also able to better withstand extreme heat and cold.

The genetic salt resistant resources of the Dead Sea could be very important for revolutionizing saline agriculture around the world. If transformation of this gene and other genes is cloned, it will be possible to improve crop production by making them salt tolerant and enable the growth of crops like wheat in a tepid desert area. The idea is to develop a battery of salt resistant genes to be used for crop improvement.

CIMMYT to engineer drought tolerance

The publicly-funded International Maize and Wheat Improvement Center (CIMMYT) has been involved with crop improvements since the green revolution. Both transgenic and traditional breeding approaches to crop improvements are used. A drought tolerant transgenic wheat variety is being evaluated and may be ready for commercialization within five years. However, an interesting twist has been discovered with this research project. It seems that under drought conditions the transgenic wheat does better than non-transgenic varieties, but under adequate water conditions the transgenic wheat performs less well. Therefore, researchers are looking for ways to control when the transgene (gene engineered into a crop) is turned on.

There has been some excellent research looking at controlling pieces of DNA, called promoters, which will only turn genes on under specific environmental conditions. Using this controlling DNA is a type of genetic use restriction technology (or GURT). Although critics of GE crops have been very active fighting the advancement of GURT research, Canada is one of a select number of countries that has called for more research into using these technologies to improve crops. Further, the use of another type of GURT would stop the unwanted movement of the drought tolerance trait itself. Using this type of GURT the pollen or seed of the drought tolerant crop would be sterile so there would be no transfer of the drought resistance into other crops or natural weed populations.

The most popular type of genetically engineered crop grown around the world is engineered to be herbicide tolerant. Growing these crops results in excellent weed control and at the same time allows the farmers to practice reduced or zero tillage agriculture. The benefits have been well documented. By reducing the amount of ploughing, soil erosion and the loss of soil moisture to evaporation are greatly reduced. Therefore, growing this type of GE crop also helps with water conservation.

The other big players in agriculture biotechnology are also heavily investing in drought tolerance research. Bayer, Syngenta, Dow, BASF and Dupont all have extensive research programmes in this area. At this point no one knows how many drought tolerant transgenic crops China has in development. But we can be confident it is quite a few as China has three times as many transgenic crops in development as the United States. The adoption rate of agricultural biotechnology is fastest in developing world. If the current trend of climate change continues there will undoubtedly be shifts in precipitation patterns around the world. Those areas that rely on rain water for agriculture may be at risk. Along with newer drip irrigation systems, agri-forestry, and traditional plant breeding, genetic engineering of drought tolerance will play an important role in maintaining food production with less water.

Local plants for pest control

Kenyan scientists have turned to traditional methods of pest control in a bid to produce a new variety of genetically modified cotton. The scientists conducting trials at the Kenya Agricultural Research Institute (Kari) at Kimbimbi in Mwea, Kirinyaga District, are testing the efficacy of tobacco and neem leaf powder in eradicating the destructive bollworm. Researchers at the station said that they have been spraying the genetically modified cotton, codenamed HART 89 M, with the powder for one year. The chief researcher of the project said that some consumers of cotton products in Europe were ready for higher prices of genetically modified cotton. But the scientists decried lack of a legal framework regulating biotechnology, saying it had hampered research.

Funding for alternative research approach

There are some recent initiatives which are important in the sense that they intend to emphasize the relevance of alternative approaches. We present such initiatives from Divergence Inc. from US, DEFRA from UK and by the European commission. Divergence Inc. has received three federal grants, totaling $280,000, to develop a new method of creating genetically modified plants. The company, based at the Nidus Center for Scientific Enterprise incubator in Creve Coeur, announced that its first target is biotech crops that can resist harmful nematodes, also known as roundworms. But the technology platform, if it works, could be used to transfer a variety of beneficial genetic traits to plants. Divergence received two small-business innovation research grants from the National Science Foundation and one from the U.S. Department of Agriculture. Since 2001, the company has been awarded 12 innovation research grants totaling more than $2.5 million.

In case of Defra, the British Department for Environment, Food and Rural Affairs, a methods for containing the spread of novel genes in GM crop plants is developed. This issue is of potential relevance to the risk assessment of new types of GM crop. The review was considered in near-final form by the independent Advisory Committee on Releases to the Environment.

The European Commission is devoting $12 million to AGRONOMICS, a plant research consortium of the Flanders Interuniversity Institute for Biotechnology (VIB) and Ghent University. The goal of this 5-year initiative led in collaboration with other top European research institutes is to understand the network of biological processes involved in leaf growth. With the exception of the Arabidopsis genome initiative, this is arguably the largest grant ever awarded in this area of research, and a clear indication of the social importance of a deep understanding of life processes in plants.

The Department of Plant Systems Biology, in collaboration with nine other top European research institutes, has set out to perform an in-depth study of leaf growth in the model plant species Arabidopsis thaliana. To support their efforts, these scientists launched an initiative called AGRON-OMICS (Arabidopsis GROwth Network integrating OMICS technologies). In the coming five years, this network of major European players in plant biology will perform experiments to identify the molecular components controlling growth and build mathematical models to explain how these components interact.

USDA to approve second genetically-modified fruit

The U.S. Department of Agriculture (USDA), Institute National de la Recherche Agronomique of France and Cornell University are planning to introduce genetically-modified plums for commercial use. This would make plums the second genetically engineered fruit along with papaya to be approved for commercial use. As a result, many consumer, health, and environmental advocacy groups are now on alert for their potential arrival on the market. The genetically modified variety of plum, called c5, will enable it to resist the mutation of the Plum Pox Virus among stone fruit trees. The virus has had commercial growers and government officials otherwise at a loss about how to contain it.

First found in Adams County, Pennsylvania and in the Canadian provinces of Ontario and Nova Scotia, Plum Pox Virus is considered to be the most serious virus disease of stone fruit, with the potential to devastate stone fruit production. One organization, the Organic Consumers Association, indicated in a nationwide action alert that since the new plum tree will be the first GE temperate tree proposed for commercial planting, it could open the door to the commercialization for other GE varieties of temperate trees-such as poplars, pines, or walnuts. Flowers and fruit in organic and conventional plum orchards can be contaminated if pollen from GE trees were transported by bees and other insects that often travel long distances. Should contamination occur, the result is that organic, or even conventional plum growers will lose their markets.

Recent trials with other GE fruits have confirmed this to happen. Jeffrey Smith, author of the book *Seeds of Deception* recently wrote in a July e-newsletter that introducing GE papaya in the state of Hawaii did not show the results scientists wanted, and in fact, made the situation worse than before. The USDA does admit that the GE plum will contaminate both organic and conventional non-genetically engineered plum orchards, if approved. Since all commercial plum trees are cultivars (a plant variety created intentionally and maintained through cultivation) that are cross compatible within the same species, contamination will infiltrate the plum orchards of organic and conventional growers.

Private Sector and Biotechnology

Commercialization of new Bt cotton variety

Andian firm JK Agri Genetics Ltd has signed an agreement with the National Botanical Research Institute, Lucknow (a CSIR Institute) to commercialise their new Bt cotton technology by using Cry IEC gene in India. The firm has recently launched the first indigenously developed Bt Cotton in Indian market after getting clearance from GEAC, the product was first developed under collaborative research with BREF-IIT Kharagpur. The new gene (Cry IEC) developed by NBRI would be pyramided with the recently released material carrying Cry 1Ac gene. This elite Bt Cotton will give broader insect resistance coverage, particularly against Spodoptera (tobacco caterpillar) and is expected to provide season long uniform protection against the target pests throughout the entire field. Besides this, the new product would also help in delaying the resistance development in Cotton Bollworm complex. Currently cotton varieties containing Bt do not offer acceptable control of Spodoptera.

US debate over biotech and taxes

Some of the state of Arizona's most prominent business leaders are being criticized by a few of their private-sector brethren and conservatives for coming out against sweeping income tax cuts and backing an incentive fund aimed at attracting biotechnology to the state. Greater Phoenix Leadership (GPL) is feeling the blowback after a recent meeting with Republican legislators in which the group voiced skepticism toward a proposed 10 per cent income tax cut and strong support for the Arizona 21st Century Competitive Initiative Fund. That fund would be used to help fund research, startup companies and other life-science endeavours. In addition, it would subsidize the new Science Foundation Arizona, which is slated to get a $100 million donation from Scottsdale real estate developer and philanthropist Jerry Bisgrove.

Current Republican budget plans call for $15 million from existing job-training funds to be allocated to the newly established 21st Century Fund. The governor, GPL and other backers of the biotech programme want more money put toward the fund but don't want it to come from job-training pools. They say the fund is key to attracting and growing the biotech sector in the state. GPL opposition to income tax reductions and its support for the governor's spending plans is drawing criticism from business groups backing major tax cuts and Republican rivals of the governor.

GPL is very supportive of the proposed 21st Century Fund and has concerns about the financial impact of income tax cuts. They see taxes and biotech as two separate issues, and the state needs to invest in education, economic development and transportation. GPL feels a new round of proposed business-backed property tax cuts as "reasonable," but added his concern over income tax reductions and its result in future deficits.

A number of major business and real estate groups favour property tax reductions. They feels that large tax cuts may result in future budget deficits. Other critics of the income tax and property tax cuts argue that it will disproportionately help the wealthy and large commercial property owners. Some major business groups are supporting tax cuts and stress the business community has a diversity of views on taxes, spending and how to attract jobs.

Public-private partnership to develop GM wheat

BASF Plant Science and Australian research centre Molecular Plant Breeding CRC strengthen cooperation to develop genetically optimized wheat. BASF Plant Science and the Molecular Plant Breeding Cooperative Research Centre (MPBCRC) announced the expansion of their joint research and development programme. The aim of BASF's seven year, 17 million programme, is to develop high yielding wheat varieties that are also more resistant to fungal diseases and adverse environmental conditions such as drought. As part of the programme, BASF Plant Science is making available its collection of gene candidates for yield increase, drought tolerance and fungal disease resistance.

Global seed market and Monsanto's profit and market share

Shift in global crop production base, transgenic and hybrid seed technologies and changes in targeted plant populations helped in increase in the value of the global proprietary seed market to more than $17 billion in 2005. The increase is more than 30 per cent over the past five years. According to the latest edition of an extensive global seed market survey completed by The Context Network, the "expanded plantings of oilseed crops and maize (corn) and the continued adoption of biotech seed are two mega trends that are pushing up the value of and importance of proprietary commercial seed globally."

Monsanto earned $334 million, or $1.21 per share in the third quarter, compared with $47 million, or 17 cents a share, a year earlier. Net sales rose to $2.35 billion from $2.04 billion a year earlier. The company cited greater adoption of its genetically modified corn seeds as a key driver of growth, as well as a research-and-development write-off that weighed down profits a year ago.

Monsanto's American Seeds Inc. subsidiary has bought five regional Corn Belt companies for a total of $77 million, bringing ASI's share of the U.S. corn seed market to nearly 6 per cent. Dekalb and Asgrow, Monsanto's in-house seed brands, captured an additional 16 per cent of that market last year — following a trend of year-over-year growth that began in 2002 and is expecting to continue this trend in near future also. Adding more than 250 independent regional seed companies that license Monsanto's seed technology, its products encompass more than half of the corn seed purchases made by American farmers. It is developing second-generation biotech corn seeds — hoping to add drought tolerance and improved nitrogen absorption to its stable of seeds genetically modified to withstand destructive pests, or applications of glyphosate herbicide, which Monsanto sells as Roundup. The company also is expanding its hybrid offerings by using molecular analysis to identify and cross-breed high-yielding and better-performing strains.

Bayer signs collaborations in CropSciences

Bayer Innovation GmbH and greenovation Biotech GmbH has signed a licensing and service agreement in the field of protein Glycosylation in plants. Glycosylation is a process by which certain sugar molecules are added to proteins in plants. Understanding and controlling this process in plants can enable researchers to enhance considerably the activity or bioavailability of new proteins produced by plants which can be used for therapeutic purposes

Cellectis SA, the national genome engineering company, and Bayer BioScience NV, a Belgian subsidiary of Bayer CropScience have signed an agreement under which Bayer CropScience will have access to Cellectis' proprietary custom-made Meganuclease technology for use in plant research and to develop products for use in agriculture. Meganucleases are a proprietary genome engineering technology developed by Cellectis allows for highly precise 'editing' to genetic sequences. They consist of sequence-specific endonucleases with large (>18-24 bp) recognition sites. This high specificity ensures Meganucleases can bind and cut at a single point in a chosen genome without the imprecision associated with most other forms of gene modification. Custom-made Meganucleases can be designed for very specific gene targeting applications. Bayer CropScience will use custom-made Meganucleases in plant research and the development of new products.

Delta and Pine Land Company acquires technology licenses from DuPont

Delta and Pine Land Company has acquired several licenses from DuPont including its Optimum(TM) GAT(TM) herbicide tolerance technology for cotton and soybeans, enabling the Company to enhance its leading product portfolio. In addition to this, the Company has acquired licenses for other products developed by the DuPont biotechnology research programme and certain enabling technologies for use in cotton, soybeans and other crops. Optimum(TM) GAT(TM) trait developed by DuPont will provide farmers with expanded weed control options and will help in optimizing yield. This herbicide tolerance technology makes plants tolerant to both glyphosate and ALS herbicides, including sulfonylureas.

GM debate in Africa

Researchers from Africa found that GM crops are coming in by way of food imports and seed smuggling, even for countries that have taken measures to prevent imports of GM foods, such as Zambia, Angola, Sudan and Benin. In short, the researchers argue that Africa is in danger of becoming the dumping ground for the struggling GM industry and the laboratory for frustrated GM scientists.

South African farmers grew more than 1.2 million acres (480,000 hectares) of biotech corn, soybeans and cotton in 2005. Plantings have significantly increased each year since commercial-scale introduction in 1997; enabling these farmers to increase their incomes by US$56 million and reduce pesticide applications by 330,000 pounds (150,000 kg)

Mr. Zachary Makanya, in his well-researched paper entitled "12 reasons for Africa to reject GM crops," says that the proponents of GM technology sell a sweet message of GM crops as the second green revolution and the answer to African hunger, but the reality is quite different. A close look at GM crops and the context under which they are developed makes it clear that GM crops have no place in African agriculture.

GMOs are the on the frontline of one of the biggest conflicts of recent years between the science-business community and activist groups. Many of these feel that, in addition to environmental concerns, with four big multinational companies dominating the global biotech market, the proliferation of patented GMOs will give corporations an unhealthy control over food production. Apart from other problems related to GMOs, researchers say that GM crops will foster dependence on a corporate seed supply. Most GM seed manufacturing companies prohibit farmers from saving their on-farm produced seeds for the next season and from sharing them with their neighbours, relatives and friends. This is imposed through elaborate contracts, agreements, and conditions, which are imposed by the multinational GM seed companies.

There is a study that says that more than 80 per cent of the small-scale farmers in Africa today save their on-farm produced seeds for the next season. Farmers sometimes do this because they do not have enough money to buy new seeds and sometimes because they value their own seeds. Also, seed sharing is a crucial norm in many African communities. The fear is that the introduction of GM seeds will jeopardize these traditional and vital practices. The environmentalists say that seed saving gives farmers life, and seed monopolies rob farmers' life and makes free resources available on farm, a commodity to which farmers are forced to buy every year. This is a shift from biodiversity to monoculture in agriculture, and monoculture increases the risk of crop failure.

A high-level panel of experts warned that Africa might be forced to consume genetically modified food products made from other continents in future if it fails to nature its own research capacity on genetic modification (GM). The Nairobi-based African Agricultural Technology Foundation said that Africa was already too dependent on everything and that taking an early lead in scientific research was one way to ensure it not to become over dependent in the future. This panel needs to recommend what Africa needs to do. We must keep building on what we have already done.

In a conference on food security and the challenges of genetically modified organisms (GMOs) at Harare participants raised pertinent questions on the need for African governments to set clear guidelines on GMOs when it comes to food aid as well as the general consumption of other GMO products. It was suggested that Africa must resist pressure from multinational corporations that continue flooding the agro-business sector with genetically modified organisms (GMOs) until

Africans understand the implications of genetic engineering on biodiversity, the environment, farmers as well as consumers. It is worrying that the majority of people in Africa have become consumers of foods that they have no knowledge of how they were produced and manufactured.

Delegates agreed that the adoption of GMO technology and food aid was not the panacea to hunger in Africa. There are huge risks to the smallholder rural African farmers if they adopt GM-crops. Experience highlights the danger of dependency and monopoly control over GM seed by multinationals. Large multinationals have monopoly through their country agents, subsidiaries and joint-venture exercises on the price of the GM seed eroding the rights of the poor farmers to other alternatives.

New genetically engineered seed, known as "suicide" or "terminator" seeds which were engineered to be sterile, forced poor farmers to repurchase seed each year from the multinationals who have patented these 'genetic use restriction technologies'. These GM seeds, included "junkie plants" that were dependent on chemicals sold by multinationals to flower, seed or sprout. Farmers using GM crops in South Africa had to sign contracts with Monsanto, a giant GMO corporation, where they agree not to share their seed, only use Monsanto chemicals, buy new seed the following year and agree to set aside 25 per cent of their land as a "refuge" area to control diseases.

Participants felt that GM seed would increase the dependency and indebtedness of smallholder farmers to multinationals eroding the communal rights, which entitled them to traditional crop varieties, which they would share freely without added costs. Critics say that most South Africans are not aware that they are consuming GM foodstuffs due to lack of information, labelling and the monopolistic influences of the multinationals when it comes to media advertising, lobbying government and the funding of stooge NGOs which support the proliferation of GMOs for profit.

Experts fear that genetic engineering in agriculture is likely to have adverse environmental impacts that may affect the ecological basis of food production. They say GM crops will stimulate the growth of "superweeds" and "superbugs" leading to the use of higher doses of chemicals making food supplies more vulnerable to pest damage. Adoption of GM crops may lead to reduced genetic diversity resulting in fewer and fewer types of food crops. This, in turn, may increase the likelihood of pest and disease epidemics. This calls for the region to develop collective regional policies on food aid that address the array of potential risks in all facets of the technology.

In light of the controversy and public concern over GMOs, it was concluded in the conference that: "It is imperative that an immediate freeze on genetic engineering on food and farming is declared throughout Africa until we have assessed and understood all the implications for consumers, farmers and the environment."

GM products in South Africa

A multi-billion shilling research project by a Kenyan scientist to develop a genetically modified sorghum type has been suspended. The project was expected to come up with a new variety of sorghum to help alleviate hunger in the sub-Saharan Africa. South Africa had expressed concern over the possible contamination of the sorghum varieties native to Africa by the introduction of a genetically modified type.

The government said they could not grant the permits on the basis of information provided and asked for additional information which is going to be provided. Prof Wambugu is optimistic that the project would eventually take off after she addressed the concerns raised by Department of Agriculture's Council for Scientific and Industrial Research, which regulates research in bio-technology in South Africa.

Ghana to have biosafety legislative framework

In a three-day workshop for the media in Accra on the relevance of biotechnology by the United States Agency International for Development (USAID) and Africa Bio (an NGO based in South Africa) it was conveyed that while the bill is awaiting cabinet approval, there is the need to develop and apply a biosafety legislative framework in order to govern the introduction of Genetically Modified Organisms (GMOs) adding that they are becoming increasingly common as the country applies more modern technologies. USAID aims at developing a strategic plan and to create awareness on issues of biotechnology among various stakeholders nationwide. The proven and potential benefits of modern biotechnology are accepted as means of increasing food production efficiency, of ensuring sustainable agriculture and of developing new products from and uses for different plant varieties. Public awareness based on factual information is required to enable consumers to make informed decisions.

ITPGRFA to work on MTAs

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) under the aegis of FAO concluded in November 2001. This legally-binding Treaty covers all plant genetic resources relevant for food and agriculture. It is in harmony with the Convention on Biological Diversity.

The Governing Body of the Treaty, which will be composed of the countries that have ratified it, will set out the conditions for access and benefit-sharing in a "Material Transfer Agreement". Resources may be obtained from the Multilateral System for utilization and conservation in research, breeding and training. When a commercial product is developed using these resources, the Treaty provides for payment of an equitable share of the resulting monetary benefits, if this product may not be used without restriction by others for further research and breeding. If others may use it, payment is voluntary. But it lacked the detailed provisions needed to implement the system.

The tough nuts-and-bolts decisions were bequeathed to the first meeting of the Treaty's Governing Body, the 104 countries that had formally ratified the Treaty when the Governing Body convened in June 2006 in Madrid.

Confounding most observers who thought the issues too technically and politically intractable to resolve, the Governing Body: (1) Agreed on the terms of a standard Material Transfer Agreement (sMTA) through which all crop diversity covered by the Treaty's Multilateral System (covering more than 35 of the world's most important crops, plus a number of forages) will be accessed and used. The sMTA calls for a royalty of 1.1 per cent of sales to be paid into a fund when (a) genetic material is accessed from the Treaty's multilateral system, (b) it is incorporated into a product that is a plant genetic resource, such as a new crop variety, (c) the product is commercialized, and (d) there are restrictions, such as patent protection, that limit use of the product for further plant breeding and research. Users can opt for a lower royalty rate (0.5 per cent) if they apply it to all products of a particular crop regardless of whether there are restrictions to further use and regardless of whether multilateral system materials were used in making them. The Treaty's Governing Body will control and dispense funds raised, using them to support crop diversity related programmes. (2) Agreed on a financial strategy for implementation of the Treaty and Rules of Procedure for the Governing Body. (3) Approved the text of agreements bringing collections held by the CGIAR under the terms of the Treaty. These collections contain much of the diversity of the world's major crops and are the most widely used collections in the world. (4) Expressed in the final report of the meeting its "unanimous support" for the Global Crop Diversity Trust and approved and signed a Relationship Agreement with the Trust recognizing, uniquely, the Trust's role as an "essential element" of the Treaty's funding strategy in regards to *ex situ* conservation and availability of plant genetic resources.

The Treaty removes the uncertainty of access and the fear of exploitation that prevailed in the 1990s – uncertainty and fear that choked off exchanges of crop diversity and undercut conservation and plant breeding efforts. The first meeting of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture (Madrid, 12-16 June 2006) highlights the importance of conserving the genetic material. It was said that "crop, forest, animal and fish genetic resources represent an insurance against future changes in production and climatic conditions or in market needs. They are also a source of material for scientific research as well as a cultural and historical part of mankind's heritage." Numerous new and old biotechnologies provide a broad collection of tools that can be applied for a range of different purposes (genetic improvement; disease diagnosis; vaccine development; etc.). They include molecular markers, cryopreservation and reproductive technologies that can be used directly for the characterization and/or conservation of genetic resources for food and agriculture. Characterization of genetic resources goes hand in hand with their conservation since it is fundamental both for understanding what is being conserved and for choosing the genetic resources that should be conserved.

The ability to apply these biotechnologies in developing countries is currently limited by the lack of sufficient funds, human capacity and adequate infrastructure. It can be strengthened through greater collaboration among research institutions in different developing countries and also between industrialized and developing countries.

Document

OECD Report on Biotechnology Statistics*

Biotechnology is used for producing existing products in new ways, identifying new product opportunities (as in drug discovery), and for producing new products that could not be commercially produced before (as with many large molecule therapeutics and some GM plant varieties). The wide range of uses for biotechnology means that it is a generic technology with applications in many different economic sectors. Biotechnology is also better described as a group of related biotechnologies.

The diverse types of biotechnologies and the range of possible applications create two main challenges for developing comparable biotechnology statistics: how to defined biotechnology and how to define a biotechnology firm.

Definition of Biotechnology

The OECD has developed both a single definition of biotechnology and a list-based definition of different types of biotechnology. The single definition defines biotechnology as *"the applicatin of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the productin of knowledge, goods and services."*

The OECD list-based definition, or close variants, were used in surveys in 15 countries, but different definitions of biotechnology were used in the other 11 countries: seven studies limit biotechnology to 'modern' or third-generation biotechnologies that are similar to the OECD list-based definition in practice, two studies use mixed definitions that include second generation biotechnologies (Japan and South

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* Beuzekom, Brigitte van and Anthony Arundel (2006). *OECD Biotechnology Statistics 2006*. OECD.

Africa), and two do not define biotechnology, but leave it to the survey respondent to decide if their firm is active in biotechnology. As the latter two studies cover Denmark and Sweden, a large majority of the respondents are likely to interpret biotechnology as modern biotechnology.

Definition of a Biotechnology Firm

The definition of a biotechnology firm is partly linked to the method used in each country to sample firms. Three definitions are in common use. Two different methods are used in separate studies in Finland, Korea, New Zealand, Spain, Sweden and the United States.

Data are only available for 'core' biotechnology firms for seven countries. The definition of a core biotechnology firm varies, but in most countries a core biotechnology firm must perform R&D in biotechnology and biotechnology must be its principal activity. The latter requirement often limits core biotechnology firms to those with less than 500 employees.

At least some of the data for the remaining 19 countries cover all firms with some bitechnology activities, even if biotechnology is only a small part of its total activity. In 13 countries biotechnology firms are identified through a positive response to a question on conducting biotechnology-related R&D in the national R&D survey. In nine countries all biotechnology firms were surveyed (core firms plus other firms with some biotechnology activities). No information on the definition of a biotechnology firm is available for Poland.

In 20 countries at least one survey is limited to firms that develop biotechnology innovations. For four countries, the only available survey includes firms that use biotechnology but do not necessarily perform biotechnology R&D. No data are available for Belgium and China on this issue.

Two main methods are used for identifying biotechnology firms. Eighteen surveys use secondary sources to identify biotechnology firms. These include industry association membership lists, participants in government programmes to support biotechnology, stock market listings, patent records, information provided by venture capital firms, and any other possible source for identifying a biotechnology firm. Thirteen surveys use the national R&D sampling frame. The survey in Korea is based on activity in specific sectors, with no information is available for Poland.

In general, the results in this document (for all countries combine) for the number of biotechnology firms, employment, R&D and sales are more likely to underestimate the true values than to overestimate them. This is primarily caused by the reliance for several countries on studies limited to core biotechnology firms and the low response rates in several studies.

Bio Web

Global Biotechnology Industry Organizations

Australia Biotechnology Organization (AusBiotech)

AusBiotech represents over 2,400 members, covering the human health, agricultural, medical device, environmental and industrial sectors in biotechnology. AusBiotech is dedicated to the development, growth and prosperity of the Australian biotechnology industry, by providing initiatives to drive sustainability and growth, outreach and access to markets, and representation and support for members nationally and around the world.
http://www.ausbiotech.org/

The Danish Association of Biotechnology Industries (DANSK BIOTEK)

DANSK BIOTEK furthers the conditions for biotechnological research and production in Denmark. DANSK BIOTEK has primarily been active on two fronts: an ongoing dialogue with authorities and as an authoritative voice in the public debate about biotechnological issues. DANSK BIOTEK has contributed to the creation of legislations and regulations on biotechnological research, production and patenting in Denmark and Europe.
http://danskbiotek.customers.composite.net/composite-13.htm

The Danish Biotechnology Instrument Center (DABIC)

DABIC was established through funds from the Danish Research Councils in November 2000. The objective of DABIC is to promote biotechnological research in Denmark through a closer co-operation between private industry, semi-private institutions and research facilities at public institutions.
http://www.dabic.dk/

Finnish Bioindustries FIB

Finnish Bioindustries FIB is Finland's biotechnology industry association, established in 1997. It is a private, independent non-profit organization. Member companies represent all life science areas, from health care and functional food to biomaterials. In addition, industry organizations such as Chemical Industry Federation, Pharma Industry Finland, Finnish Food and Drink Industries' Federation, Finnish Forest Industries Federation and Finnish Crop Protection Association are members of FIB.
http://www.finbio.net/

French Biotechnology Association

France Biotech is the French biotechnology association and the industry representative. Its mission is to contribute to position France and Europe as leaders in the life sciences industry. France Biotech is acting on the success for a strong biotechnology industry, improving the academic R&D dynamics and funding. France Biotech supported the Strategic Council for Innovation (SCI) when it made a series of proposals including the creation of a National Science Agency.
http://www.france-biotech.org/

German Association of Biotechnology Industries (DIB)

DIB is Germany's trade association for industrial biotechnology. DIB speaks for more than 200 large, medium-sized, and small member companies engaged in research, development and production of pharmaceuticals, diagnostics, agro-biotech products, enzymes, food additives, and others. Around half of DIB' membership are newly established entrepreneurial biotech companies.
www.dib.org/default.asp

The Israel Biotechnology Organization (IBO)

IBO operates within the Manufacturers' Association of Israel in order to promote the interests of the Biotechnology Industry in Israel, and to create a supportive business environment for the development of the Biotechnology Industry. IBO comprises approximately 50 biotechnology companies that are divided into two branches: pharmaceutical biotechnology and agricultural biotechnology. IBO

operates in collaboration with the Israeli Government Ministries and other sectors in order to advance the biotechnology industry in Israel.
http://www.irc.org.il/biotech/option3.htm

Japan Bioindustry Association (JBA)

JBA is a non-profit organization dedicated to the promotion of bioscience, biotechnology and bioindustry in both Japan and the rest of the world. Established through the support and cooperation of industry, academia, and government, JBA is the only organization of its kind in Japan. JBA's roots date back more than 50 years to the establishment of the Japanese Association of Industrial Fermentation. Today, like its predecessor organization, the JBA functions as a think tank and platform for communication between scientists, technologist, policymakers and managers.
http://www.jba.or.jp/index_e.html

All India Crop Biotechnology Association (AICBA)

The All India Crop Biotechnology Association (AICBA) is an industry association of the major companies engaged in agricultural biotechnology in India and is registered under the Societies Registration Act. The Association counts among its members, a total of 15 leading Indian seed companies engaged in agriculture biotechnology including most of the multinationals. Some are also technology providers.
http://www.aicba.com

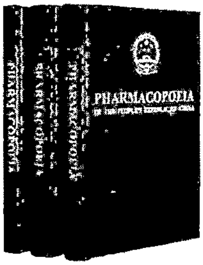
Biotechnology Industry Organization (BIO)

In 1993, when there were but a handful of biotechnology drugs on the market and the sequencing of the human genome was pegged for completion somewhere around 2005, two small Washington-based biotechnology trade organizations merged to create the Biotechnology Industry Organization, better known as BIO. One of the founding organizations, the Industrial Biotechnology Association (IBA), primarily represented larger, established companies on Capitol Hill and before federal regulatory agencies; the other, the Association of Biotechnology Companies (ABC), represented emerging companies and universities, and focused on technology transfer issues, meetings

and other business development activities. BIO united the organizations' 503 companies and 18 employees under one umbrella with a representative governing board that reserved one-third of its seats for emerging companies.
http://www.bio.org/aboutbio/history.asp

New Arrival

The *Pharmacopoeia of The People's Republic Of China*



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Business Data International Inc., the business and professional information provider, has recently announced that an English Version Chinese *Pharmacopoeia, compiled by the Pharmacopoeia Commission of the Ministry of Public Health,* has just been published. The Chinese *Pharmacopoeia 2005* (CP 2005) is the only authoritative collection of standards for Chinese medicinal substances and an essential reference point for everyone involved in their research, development and manufacture. With Chinese standards constantly changing, only the CP 2005 can assure you of complete compliance within China.

The Chinese Pharmacopoeia 2005 is published in three volumes, which contains up to 3214 monographs of drugs, with 525 new admissions in total. Volume I contains 1146 monographs (with 154 new admissions and 453 revised) of Chinese material medica and prepared slice, vegetable oil/fat and its extract, Chinese traditional patent medicines, single ingredient of Chinese crude drug preparations etc.; Volume II covers 1967 monographs (with 327 new admissions and 522 revised) of chemical drugs, antibiotics, biochemical preparations, radiopharmaceuticals and excipients for pharmaceutical use; Volume III contains 101 monographs (with 44 new admissions and 57 revised) of biological products.

Public Sector Biotechnology R&D

Data on public sector expenditure on biotechnology R&D are available for 10 countries. The results for Canada is for R&D expenditures in the public sector that are financed by the Federal Government. Data the United Kingdom (UK) is limited to government expenditures in public research institutions, and for Sweden the results are limited to government expenditures in higher education institutions. In the other countries the results refer to all expenditures by government research institutes and higher education institutions.

Public and Private Sector Expenditure on R&D in Biotechnology, 2003

Country	Public R&D Expenditure on Biotechnology	Share of Public Biotech R&D Expenditure in total Biotech R&D Expenditure by Public and Private Sector
Iceland	5.1	7.1
Sweden	28.5 (1.3)	
Norway	90.2 (6.0)	75.5
Finland	104.7 (6.7)	54.2
Denmark	131.3 (9.9)	15.3
New Zealand	148.7 (24.2)	61.0
UK	211.8 (1.6)	
Spain	452.6	69.5
Canada	549.4 (12.4)	31.5
Korea	727.4 (15.3)	58.0

Notes: 1. For Denmark data is for the year 2002.
2. For New Zealand and Spain data is for the year 2004.
3. Figures in parenthesis are share of public expenditure on R&D in Total Public R&D.
4. Absolute values are in US $ Million PPP.

Source: Beuzekom, Brigitte van and Anthony Arundel (2006). OECD Biotechnology Statistics 2006. OECD.

Out of the ten countries, Korea has the highest level of government expenditures on biotechnology R&D, at PPP$ 727.4 million, followed by Canada and Spain. Biotehnology R&D expenditures in Korea have increased 63.1 per cent in two years, reaching PPP$ 1186.6 million in 2005.

The percentage of all public sector R&D expenditures due to biotechnology is a measure of the government's focus on biotechnology research. New Zealand has the highest share, at 24.2 per cent followed by Korea (15.3 per cent) and Canada (12.4 per cent). The results for the United Kingdom and Sweden are less than 2 per cent but in both of these countries the data only capture a part of total government R&D spending.

Although the Norwegian public sector spends comparatively little on biotechnology R&D, public expenditure account for 75.5 per cent of all biotechnology R&D (public and private sector combined). The majority of biotechnology R&D is performed within the public sector in Spain (69.5 per cent), New Zealand (61 per cent), Korea (58 per cent) and Finland (54.2 per cent). Conversely, only 7.1 per cent of total biotechnology R&D in Iceland is performed in the public sector, and 15.3 per cent in Denmark.

Announcement

Asian Biotechnology and Development Review

Vol. 9 No. 1 November 2006

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Terry Kaan

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1. Articles should be submitted in duplicate to the Managing Editor, Research and Information System for Developing Countries (RIS), India Habitat Centre, Zone IV-B, Lodhi Road, New Delhi 110003, India (Tel. 00-91-11-24682177-2180, Fax: 00-91-11-24682173/2174, E-mail: sachin@ris.org.in) Manuscripts should be accompanied by a floppy disc in IBM compatible format, preferably in MS Word, identical in every respect to the hard copy typed on A4—paper on one side only, double-spaced throughout and with ample marging on all four sides.
2. ABDR is multi disciplnary journal. Please explain technical details in simple words for the benifit of non-technical readers.
3. Use 'z' in '-ize' '-ization' words; e.g., 'civilize', 'organization'. Use British spellings rather than American spellings. Thus, 'labour' not 'labor'.
4. Use figures (rather than world) for quantities and exact measurements including percentages (2 per cent, 3 km, 36 years old). In general descriptions, numbers below 10 should be spelt out in words. Use thousands, millions, billions, not lakhs and crores. Use fuller forms for numbers and dates— e.g., 1980-88, pp. 200-202 and pp. 178-84.
5. Specific dates should be cited in the form June 2, 2004. Decades may be referred to as 'the eighties'. Spell out 'the twentieth century', etc.

References: A list of references cited in the article and prepared as per the style specified below should be appended at the end of the article. Reference must be typed in double space, and should be arranged in alphabetical order by the surname of the first author. In case more than one work by the same author(s) is cited, then arrange them chronologically by year of publication.

All references should be embedded in the text in the anthropological style – for example '(Hirschman 1961)' or '(Lakshman 1989:125)' (Note: Page numbers in the text are necessary only if the cited portion is a direct quote)

Citation should be first alphabetical and then chronological – for example 'Rao 1999a, 1999b'.

More than one reference of the same date for one author should be cited as 'Shand 1999a, 1999b'.

The following example illustrate the detailed style of referencing:

(a) Books:

Hirschman, A. O. 1961. *Strategy of Economic Development.* New Haven: Yale University Press.

(b) Edited volumes:

Shand, Ric (ed.). 1999. *Economic Liberalization in South Asia.* Delhi: Macmillan.

(c) Articles from edited volumes:

Lakshman, W. D. 1989. "Lineages of Dependent Development: From State Control to the Open Economy in Sri Lanka," in Ponna Wignaraja and Akmal Hussain (eds): *The Challenge in South Asia: Development, Democracy and Regional Cooperation.* pp. 105-63. New Delhi: Sage.

(d) Articles from Journals:

Rao, M.G., K. P. Kalirajan and R. T. Shand. 1999. "Convergence of Income across Indian States: A Divergent View". *Economic and Political Weekly,* 34(13): 769-78.

(e) Unpublished Work:

Sandee, H. 1995. "Innovations in Production". Unpublished Ph.D thesis. Amsterdam: Free University.

RIS A Think-Tank of Developing Countries

RIS is a New Delhi-based autonomous policy think-tank supported by the Government of India and devoted to trade and development issues. Its work programme focuses on policy research and capacity building on multilateral trade and financial negotiations, regional economic cooperation in Asia, South-South cooperation, new technologies and development, and strategic policy responses of developing countries to globalization, among other issues. The work of RIS is published in the form of research reports, books, discussion papers, policy briefs and journals.

RIS has networked effectively with other prominent policy think-tanks, government agencies, industry bodies and international organizations in Asia and other parts of the world for collaborative research and joint activities. It has a consultative status with UNCTAD, and has been accredited to the Summit Meetings of NAM and WTO Ministerial Conferences. It has conducted policy research and other activities in collaboration with other agencies, including UN-ESCAP, UNCTAD, UNU, Group of 77, SAARC Secretariat, Asian Development Bank (ADB), the World Bank, and the South Centre.

For more information about RIS and its work programme, please visit its website: www.ris.org.in.

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